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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, January 29, 1907.

Professor H. A. Miers, D.Sc., F.R.S., President, in the Chair.

Dr. James B. Mears and Mr. Thomas Crook were elected Ordinary Members of the Society.

Mr. H. L. Bowman and Dr. A. P. Young were appointed auditors of the accounts for the year ending December 31, 1906.

GENERAL MEETING.

Held in the Apartments of the Geological Society, January 29, 1907.

Professor H. A. Miers, D.Sc., F.R.S., President, in the Chair.

Twenty-two Members and four Visitors were present.

The elections of Dr. J. B. Mears and of Mr. T. Crook to the Ordinary Membership of the Society were confirmed.

The following papers were read :—

1. Experiments bearing on the order of crystallization of rock-constituents: by Professor H. A. Miers.

2. Serpentine-rock from the Tarnthaler-Köpfe, Tirol: by Dr. A. P. Young (p. 365).

3. A simple tabular arrangement of the thirty-two crystallographic classes: by Dr. J. W. Evans (p. 360).

4. A refractometer for use with mounted precious stones: by Dr. G. F. Herbert Smith (p. 354).

5. Isomorphism as illustrated by certain varieties of Magnetite: by Professor B. J. Harrington (p. 373).

A collection of Japanese Zeolites was exhibited by Mr. F. N. A. Fleischmann; an objective giving a flat field with convergent light by Dr. J. W. Evans; and an instrument for the determination of the refractive indices of solutions by Professor Miers.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, March 19, 1907.

Professor H. A. Miers, D.Sc., F.R.S., President, in the Chair.

Mr. John Parkinson, B.A., F.G.S., was elected an Ordinary Member of the Society.

Mr. L. J. Spencer reported that he had forwarded, on behalf of the Society, 947 slips relative to mineralogical, crystallographic, and petrological papers and books, published in the United Kingdom during 1906, to the Central Bureau of the International Catalogue of Scientific Literature.

GENERAL MEETING.

Held in the Apartments of the Geological Society, March 19, 1907.

Professor H. A. Miers, D.Sc., F.R.S., President, in the Chair.

Nineteen Members were present.

The election of Mr. John Parkinson to the Ordinary Membership was confirmed.

The following papers were read:—

1. On the silver deposit in the Perran mine, Perran Uthnoe, Cornwall: by Mr. F. H. Butler (p. 385).

2. On the minerals of the Silvermines district, Co. Tipperary: by Mr. Arthur Russell (p. 350).

3. On Baddeleyite from Ceylon: by Mr. G. S. Blake and Dr. G. F. Herbert Smith (p. 378).

4. Zinciferous Tennantite from the Binnenthal: by Mr. R. H. Solly and Dr. G. T. Prior.

5. On Strüverite, a new mineral: by Dr. F. Zambonini and Dr. G. T. Prior.

Specimens were exhibited by Mr. Butler and Mr. Russell in illustration of their papers.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 11, 1907.

Professor H. A. Miers, D.Sc., F.R.S., President, in the Chair.

The audited Balance Sheet for the year ending December 31, 1906, was submitted and approved.

Resolved to nominate Mr. W. Barlow, Mr. B. Kitto, Mr. Arthur Russell, and Dr. G. F. Herbert Smith in place of the four retiring Members of Council (Messrs. Evans, Gordon, Howe, and Hutchinson).

Mr. Harold Hilton was elected an Ordinary Member of the Society.

The President was appointed as Delegate to attend the Centenary Celebration of the Geological Society.

The announcement was made of the death of Mr. J. F. Walker on May 23, 1907.

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 11, 1907.

Professor H. A. Miers, D.Sc., F.R.S., President, in the Chair.

Seventeen Members and two Visitors were present.

The election of Mr. Harold Hilton to the Ordinary Membership was confirmed.

The following papers were read:—

1. Hamlinite from the Binnenthal: by Mr. H. L. Bowman (p. 389).
2. Note on faceted beads of Zinc: by Mr. T. V. Barker.
3. On Chlormanganokalite: by Dr. H. J. Johnston-Lavis and Mr. L. J. Spencer.

Fine crystals of Hopeite, Cerussite, &c., from the Rhodesia Broken Hill mines, North Western Rhodesia, were exhibited by Mr. L. J. Spencer; a large clear crystal of Apatite from Switzerland was shown by Mr. J. M. Gordon; and a group of Quartz-crystals from British Guiana by Mr. C. W. Anderson.

MINERALOGICAL SOCIETY.

ABSTRACT OF RECEIPTS AND PAYMENTS FROM JANUARY 1 TO DECEMBER 31, 1906.

Receipts.	£ s. d.	£ s. d.
Balance from 1905		48 3 5
Subscriptions—(1) current	42 0 6	
(2) arrears	11 11 0	
		53 11 6
Sale of publications by G. Savigar (1905)		5 8 10
Dividends on Stock		16 6 6
		£123 10 3

Payments.	£ s. d.	£ s. d.
Printing Magazine (No. 65)	23 16 6	
Authors' separate copies	5 6 3	
Illustrations	3 9 0	
		32 11 9
Miscellaneous Printing		5 7 0
Editor's Honorarium (1905)		10 10 0
G. Savigar for care of Stock		1 1 0
Porter's Fee		1 0 0
Postage and Parcels—		
Printers (Magazine)	1 15 7	
,, (Authors' copies)	2 9	
G. Savigar	4 0	
Hon. Secretary	15 0	
Hon. Treasurer	6 10	
		3 4 2
Investments		16 6 6
Bank Charges		0 0 9
Balance at Bank	49 17 5	
,, in Office	3 11 8	
		53 9 1
		£123 10 3

Examined and compared with the vouchers, and found correct. (*Signed*) A. P. YOUNG, H. L. BOWMAN } Auditors.

Liabilities.	£ s. d.	Assets.	£ s. d.	£ s. d.
Owing for Editor's Honorarium (1906)	10 10 0	Balance at Bank		49 17 5
,, Miscellaneous Printing	2 17 2	,, in Office		3 11 8
,, G. Savigar for care of Stock (1906)	1 1 0	Consols (£698 18*s.* 3*d.*, valued at £86)		601 1 3
,, Do. for postage (1906)	0 2 11	Balance due from Publishers (1905)	17 12 6	
,, Hon. Secretary for postage (1906)	0 11 0	,, ,, ,, (1906)	17 3 0	
,, Hon. Treasurer ,, ,, (1906)	0 6 3	,, ,, G. Savigar (1906)	5 14 3	
Excess of assets over liabilities	692 3 9			40 9 9
		Subscriptions in arrear, valued at		12 12 0
	£707 12 1			£707 12 1

The number of Life-Members on December 31, 1906, was 51.

The Stock of Publications and the value of the Library are not

THE MINERALOGICAL MAGAZINE

AND

JOURNAL OF

THE MINERALOGICAL SOCIETY.

No. 67. September, 1907. Vol. XIV.

Red silver minerals from the Binnenthal, Switzerland.

On their Crystallographical Characters.

By G. F. Herbert Smith, M.A., D.Sc., F.G.S.

And on their Chemical Composition.

By G. T. Prior, M.A., D.Sc., F.G.S.

Assistants in the Mineral Department of the British Museum.

[Read March 15, and June 14, 1905.]

FOR many years past Mr. R. H. Solly has been accustomed to spend each succeeding summer in the quest of mineral specimens in the neighbourhood of the village of Binn, Switzerland, particularly of those occurring in the white crystalline dolomite of the Lengenbach quarry, and his patient energy has been rewarded by the discovery, not only of material which has thrown fresh light on previously known minerals, but also of specimens which on examination proved to represent species new to science. Especially important was the discovery in 1903 of small, and often minute, blood-red crystals which differed both in colour and in streak from realgar, a common mineral in the quarry. From goniometrical measurement of a few crystals suitable to the purpose, Mr. Solly concluded that they belonged to two distinct species, both of which were new, and he accordingly assigned[1] to them the names hutchinsonite, after Dr. Arthur Hutchinson, Demonstrator of Mineralogy in the Uni-

[1] Min. Mag., 1905, vol. xiv, pp. 72, 74.

versity of Cambridge, and smithite, after one of the authors of this paper. Upon hearing of this discovery, Dr. C. O. Trechmann courteously sent to Mr. Solly a specimen, purchased by the former in 1902, on which he had noticed a few small red crystals. These proved on examination to differ in morphological characters from the crystals of both the previous species, and belonged, therefore, to a third new species, for which Mr. Solly proposed[1] the name trechmannite after the owner of the specimen.

In the following summer (1904) Mr. Solly carefully scrutinized every specimen that came into his hands, and was successful in finding more hutchinsonite and smithite, and also a single, well-developed crystal of trechmannite[2] springing from a crystal of tennantite ('binnite'). The search in 1905 was comparatively barren as regards the first two species, but yielded a fine crystal of trechmannite[3], which again was situated on tennantite; and again, during the summer of last year, some fine crystals of trechmannite have come to light, but scarcely any hutchinsonite and smithite were encountered.

The best of the specimens collected by Mr. Solly, together with the actual crystals measured by him, have been acquired by the Trustees of the British Museum, and in accordance with his wishes the investigation of the red minerals has been continued by the authors. In the case of the first two of the species described in the present paper, the investigation may be considered fairly complete; but it has still not been found possible to collect a sufficient amount of the third, and the rarest of these red minerals, trechmannite, for a satisfactory determination of the chemical composition.

I. Hutchinsonite.

This mineral has especial interest because it contains a considerable amount, nearly 20 per cent., of the rare element thallium[4], which had previously been known as an essential constituent in only two minerals, crookesite, in which it was first found, and lorandite. Although it occurs in smaller crystals than is the case with either of its companion species it is, at any rate so far as can be judged from the specimens which have hitherto been found, comparatively speaking, quite as common and plentiful as smithite; nevertheless, owing to its intimate

[1] Loc. cit., p. 75.

[2] Loc. cit., p. 75.

[3] Min. Mag., 1906, vol. xiv, p. 189.

[4] The discovery was announced by Dr. Prior in a letter to 'Nature', April 6, 1905, vol. lxxi, p. 534.

association with sartorite, or other sulpharsenite of lead, the selection of pure material for a trustworthy determination of the chemical composition proved a matter of extreme difficulty, and, as will be seen below, the whole amount of material collected for the purpose was very small.

1. *Morphological Characters.*

The crystals are of two different types. In the first case the mineral is found in radiating tufts of tiny needles, less than 0·1 mm. in section and less than 1 mm. in length, situated in little cavities in the dolomite. A peculiar feature of these needles added still further to the difficulty of collecting material for analysis. Both the colour and the streak varied considerably: some of the needles were a rich red in hue and gave a vermilion streak; while others, on the contrary, were much deeper in colour with a decidedly brownish tinge, and gave a deep cherry-red streak. On the other hand, the angles measured in the prism-zone, in which alone on these minute crystals were trustworthy observations obtainable, were identical within the limits of error, and both kinds display the characteristic form *g* (140). Such similarity in form and such divergence in colour seemed difficult to reconcile, and accordingly in the selection of material for analysis care was taken to keep the two kinds apart. In the second case the mineral occurs in thicker crystals, usually about 0·4 mm. in length and 0·2 mm. in section, coating crystals of sartorite and rathite. When situated on the prism-faces, the crystals of hutchinsonite are arranged in parallel position, so that their prism-edge is parallel to that of the sartorite or rathite. Somewhat shorter crystals have been deposited without any definite orientation on the terminal faces of the same crystals; and similar, but far smaller, crystals are found irregularly placed on crystals of smithite. When deposited on a crystal of a sulpharsenite of lead, the hutchinsonite forms a skin so thin that it is impossible to separate the two minerals, and in consequence a crystal of hutchinsonite removed for measurement may appear nearly black in colour and almost opaque. It may be remarked that frequently the black minerals without definite crystalline form, which are embedded in the dolomite, merge into some red mineral—probably hutchinsonite—as may be detected by scratching the surface.

In addition to the minerals on which it is actually deposited, sartorite, rathite, and smithite, the minerals associated with hutchinsonite are blende, iron-pyrites, realgar, and orpiment.

The habit of the crystals is invariably prismatic, and the dome- and

pyramid-faces are rarely developed so largely as those in the prism-zone. Indeed, in the case of the minute needles the terminal faces are so infinitesimal in size that no determination of their positions was possible. The illustrations (figs. 1–4) represent actual crystals, all of which were intimately associated with sartorite and rathite. That depicted in fig. 2 was removed from a prism-face of sartorite. The crystal shown in fig. 4 is remarkable for the large number of dome- and pyramid-faces present.

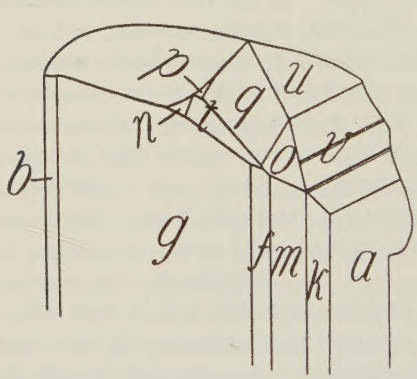

Fig. 1.

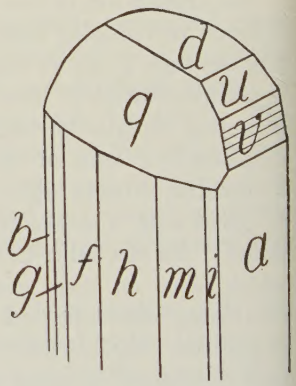

Fig. 2.

Crystals of Hutchinsonite.

The crystal illustrated in fig. 1 calls for particular note, because it alone of all the crystals examined provided any opportunity for the determination of the optical characters. Fig. 3 shows a curiously shaped crystal.

Hutchinsonite crystals are almost invariably characterized by the predominance of the form $g\{140\}$ in the prism-zone. It will be remarked how very close are certain angles in the prism- and dome-zones, e. g.:—(100):(320)=47° 27′ and (100):(201)=47° 16′; (100):(340)=65° 21′ and (100):(101)=65° 12½′. There is, however, no marked approximation to tetragonal symmetry. The parametral plane adopted is different from Mr. Solly's, his (111) corresponding to (211), and in general his (*hkl*) to (2*h*.*k*.*l*). This slight modification effects some simplification in the indices of the forms as a whole.

All the crystals were measured on the three-circle goniometer from the face $a(100)$, which was on all of them well developed, as origin, and the measurements made on the fourteen best crystals are summarized in table I. They were all small in size, and the largest did not exceed

TABLE I (Hutchinsonite).

Measurements from $a = (100)$.

Orthorhombic; $a : b : c = 1{\cdot}6343 : 1 : 0{\cdot}7549$.

Indices.	Calculated Values.		Observed Means.		Number.	Limits of Observations.	
	Azimuth.	Distance.	Azimuth.	Distance.		Azimuth.	Distance.
001	*	*	90° 0′	90° 0′	3	... 90° 15′	... 90° 29′
102	,,	77° 0′	,, ,,	77 3	3	... ...	76° 59′–77 9
304	,,	70 53½	,, ,,	70 40	1		
101	,,	65 12½	,, ,,	65 12	12	... ...	64 42 –65 30
302	,,	55 17	,, ,,	55 24	1		
201	,,	*	,, ,,	47 16	12	... ...	47 10 –47 22
703	,,	42 51	,, ,,	42 35	1		
301	,,	35 49	,, ,,	35 42	11	... ...	35 0 –36 16
401	,,	28 25½	,, ,,	28 35	3	... ...	28 33 –28 39
501	,,	23 25	,, ,,	23 34	1		
601	,,	19 50½	,, ,,	20 0	1		
825	73° 12′	54 43½	72 51	54 17	1		
012	69 19	90 0	69 21	90 1	1	69° 19′–69 23	
524	,, ,,	61 37	,, ,,	61 40	2	,, ,, ,, ,,	... 61 40
312	,, ,,	57 2½	,, ,,	57 20	1	,, ,, ,, ,,	
144	*	84 44	52 57	84 45	1	52 39 –53 6	
122	,,	79 33	,, ,,	79 34	8	,, ,, ,, ,,	79 0 –79 51
111	,,	69 46	,, ,,	69 36	10	,, ,, ,, ,,	69 15 –69 56
322	,,	61 3½	,, ,,	61 6	11	,, ,, ,, ,,	60 42 –61 25
211	,,	53 36	,, ,,	53 38	10	,, ,, ,, ,,	53 21 –54 0
522	,,	47 20	,, ,,	47 16	1	,, ,, ,, ,,	
311	,,	42 7	,, ,,	42 15	1	,, ,, ,, ,,	
411	,,	34 8½	,, ,,	34 10	1	,, ,, ,, ,,	
332	41 27	65 22	41 12	65 25	1		
142	33 31	82 44	33 25	82 15	4	33 0 – 33 40	81 40 –82 44
121	,, ,,	75 41½	,, ,,	75 38	5	,, ,, ,, ,,	75 15 –75 56
342	,, ,,	69 4	,, ,,	68 50	3	,, ,, ,, ,,	68 32 –69 1
221	,, ,,	62 58	,, ,,	62 52	2	,, ,, ,, ,,	62 49, 62 55
742	,, ,,	48 14½	,, ,,	48 14	1	,, ,, ,, ,,	
010	*	*	0 0	90 0	11	... ...	... 90 27
140	,,	81 18	,, ,,	81 24	20	... ...	81 7 –81 57
250	,,	76 15	,, ,,	76 24	1		
120	,,	72 59½	,, ,,	73 2	9	... ...	72 52 –73 6
340	,,	65 21	,, ,,	65 22	17	... ...	64 16 –65 46
110	,,	58 32	,, ,,	58 33	13	... ...	58 0 –59 16
540	,,	52 35½	,, ,,	52 30	11	... ...	52 11 –53 3
320	,,	47 27	,, ,,	47 14	10	... ...	46 52 –47 32
740	,,	43 2½	,, ,,	42 50	7	... ...	42 18 –43 7
910	,,	39 23	,, ,,	39 0½	2	... ...	39 0, 39 1
730	,,	35 0½	,, ,,	34 59	1		
830	,,	31 30	,, ,,	30 59	1		
100	,,	*	,, ,,	0 0	19		

1 mm. in the longest direction. Of the forty-two forms observed, twenty-four, viz. *a*, *b*, *c*, *G*, *F*, *l*, *k*, *i*, *m*, *h*, *f*, *g*, *Y*, *w*, *v*, *u*, *W*, *d*, *U*, *Q*, *o*, *q*, *p* and *r*, were given by Mr. Solly. The two forms (011) and (850), equivalent to (011) and (16·5·0) according to the parameters adopted in this paper, which were observed by him, have not been noticed on any of the crystals. The means of the observed values agree very closely with Mr. Solly's determinations.

In the prism-zone the forms $a\{100\}$, $k\{320\}$, $m\{110\}$, $h\{340\}$, $f\{120\}$, and particularly $g\{140\}$, are well developed; $b\{010\}$ is common, but small.

In the dome-zone the more prominent forms are $v\{301\}$, $u\{201\}$, and $d\{101\}$.

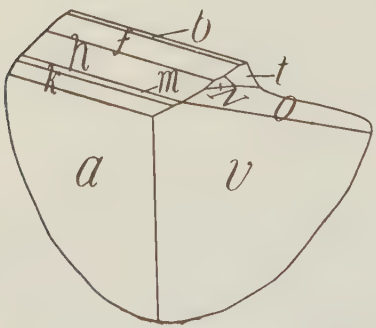

Fig. 3.

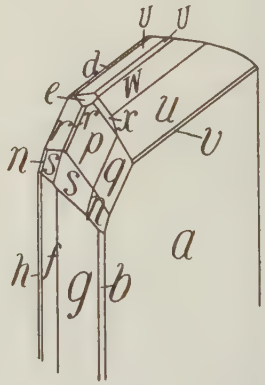

Fig. 4.

Crystals of Hutchinsonite.

In the principal pyramid-zone [100,011] the common and largest faces are those of the forms $o\{211\}$, $q\{322\}$, $p\{111\}$, and $r\{122\}$.

In the zone [100,021] the largest faces are those of the forms $t\{342\}$, $n\{121\}$, and $s\{142\}$ (cf. figs. 1, 3, and 4).

The face $\theta(825)$ is peculiar. It was only once observed, and in that case formed the only terminal face of the crystal. The natural supposition is that it is produced by some flat surface, which limited the growth of the crystal in that direction; on the other hand, it gives an unusually brilliant and distinct reflexion of the object-slit, which is not the case with pseudomorphous faces.

The remaining faces were quite minute, but gave measurable reflexions when the intensity of the image relative to the field of the telescope had been increased to the utmost.

There is a good cleavage parallel to $a(100)$, but it cannot compare with the highly perfect cleavage of smithite.

Table II comprises the coordinates of the principal forms referred to the other faces of symmetry, $b(010)$ and $c(001)$, as origins.

TABLE II (Hutchinsonite).

Calculated coordinates of the principal forms with respect to b = (010) *and* c = (001) *as origins.*

$b = (010)$.

Form.	Indices.	Azimuth.	Distance.
U	102	77° 0′	90° 0′
r	122	,, ,,	53 40
s	142	,, ,,	34 13
d	101	65 12½	90 0
p	111	,, ,,	55 35
n	121	,, ,,	36 7
W	302	55 17	90 0
q	322	,, ,,	58 11
t	342	,, ,,	38 51½
u	201	47 16	90 0
o	211	,, ,,	60 53
N	221	,, ,,	41 54
v	301	35 49	90 0
Q	311	,, ,,	66 10
w	401	28 25½	90 0
a	100	0 0	90 0
F	210	,, ,,	50 37
l	740	,, ,,	46 57½
k	320	,, ,,	42 33
i	540	,, ,,	37 24½
m	110	,, ,,	31 28
h	340	,, ,,	24 39
f	120	,, ,,	17 0½
g	140	,, ,,	8 42

$c = (001)$.

Form.	Indices.	Azimuth.	Distance.
b	010	90° 0′	90° 0′
g	140	81 18	90 0
s	142	,, ,,	33 13½
f	120	72 59½	90 0
n	121	,, ,,	68 28
r	122	,, ,,	51 43
h	340	65 21	90 0
t	342	,, ,,	31 3
m	110	58 32	90 0
N	221	,, ,,	66 8½
p	111	,, ,,	48 30
i	540	52 35½	90 0
k	320	47 27	90 0
q	322	,, ,,	44 18
l	740	43 2½	90 0
F	210	39 23	90 0
o	211	,, ,,	39 54½
Q	311	28 35	32 22
a	100	0 0	90 0
w	401	,, ,,	61 34½
v	301	,, ,,	54 11
u	201	,, ,,	42 44
d	101	,, ,,	24 47½
U	102	,, ,,	13 0

2. *Optical Characters.*

As might be anticipated from the colour of the crystals, the violet end of the spectrum is strongly absorbed, and, indeed, very little beyond the yellow is transmitted. Pleochroism is just discernible, but more by a slight variation in the intensity rather than in the hue of the transmitted light. The lustre is adamantine.

If a crystal be illuminated by monochromatic light and viewed between crossed nicols in the direction perpendicular to $b(010)$, the resulting interference-figure is of the usual kind given by a biaxial crystal in the direction of the acute bisectrix. In red light the 'eyes' are visible in the field of view, but in sodium-light they cannot be seen, even if the plate be immersed in oil. The plane of the optic axes is parallel to $a(100)$, and the usual test with a quartz-wedge reveals the double refraction as negative.

The crystal depicted in fig. 1 was mounted on the ordinary instrument for the measurement of the angle between the optic axes and dipped into pure methylene iodide, which was contained in a trough fitted with parallel glass sides. The angles between the optic axes in the oil were as follows:—

For C, $2H = 35° 19'$, and for D, $2H = 71° 58'$, where C and D are the Fraunhofer lines in the red and yellow portions respectively of the solar spectrum. As the wave-length of the illuminating light diminishes, the angle rapidly increases, and, since at the same time the intensity of the transmitted light markedly falls off, trustworthy observations in the green were found impracticable. The refractive indices of the liquid at the temperature, 18° C., of the observations are for C, 1·731, and for D, 1·740. From these values we find that $2E_r = 63° 22'$, and that in sodium-light the optic axes are internally reflected.

The same crystal was mounted on a goniometer, and it was found that light could traverse the prism formed of the large face $g(140)$ shown in the figure, and a small face of the same form lying at the back. The values corresponding to the position for minimum deviation furnish two of the principal indices. The refracted images lie very near together, and that experiencing the greater deviation is noticeably more strongly absorbed.

	Line C.		Line D.	
Angle of minimum deviation . .	37° 38′	37° 50′	39° 56′	40° 5′
Plane of polarization at right angles to	$a(100)$	$c(001)$	$a(100)$	$c(001)$
Corresponding refractive index . .	3·063	3·073	3·176	3·188
By calculation we have 2V . .	19° 44′		37° 34′	
And thence the third index . .	2·779		3·078	

The optical constants for the lines C and D of the solar spectrum are then as follows:—

	Direction at right angles to			
	a(100).	*b*(010).	*c*(001).	2V.
Line C . .	3·063	2·779	3·073	19° 44′
„ D . .	3·176	3·078	3·188	37° 34′

The particular prism-angle was 17° 20′. Since an error of 2′ in its determination would involve an error of 3 units in the third place of decimals, probably the values given above for the first and third of the refractive indices may be considered accurate to that place. But it is otherwise with the second refractive index: an error of 1 unit in the third place of one of the other indices involves an error of 6 units in the third place of decimals in the case of the yellow light, and as much as 2 units in the second place of decimals in the other case.

It will be noticed that the values are slightly higher than those of the principal indices of proustite.

3. *Chemical Composition.*

The first analysis was made on the more definitely crystallized variety of hutchinsonite, which is transparent and deep-red in colour, and gives a brilliant scarlet streak. The material consisted mainly of measured crystals, but included some fragments which showed no crystal-faces. These fragments were deep-red and transparent and exhibited no perfect cleavage like that of smithite, but the possibility that some of them may have been trechmannite is not absolutely precluded. The crystals and fragments when broken up and examined under the lens were found to be not absolutely pure, but to contain needle-like inclusions and adhering minute fragments of black minerals. These impurities were detected by means of their black or chocolate-brown streaks, and were separated under the lens as far as possible, but traces of them were doubtless present in the material analysed.

The total amount of this variety of hutchinsonite, i.e. with scarlet streak, available for analysis was only about 18 milligrams. The analysis of so small a quantity of material, though intended primarily for the qualitative determination of the constituents, was conducted as carefully as possible by quantitative methods, and the percentage numbers thus obtained are given under I, although obviously not much reliance can be placed upon them. The mineral was decomposed in chlorine, and a separation thus at once effected between the volatile

and the non-volatile chlorides. Decomposition took place readily in the cold, so that quite gentle heating sufficed to drive off completely the volatile chlorides. In the solution of the latter, only sulphur and arsenic were found. The sulphur was determined by precipitation as sulphate with barium chloride; and the arsenic by precipitation as sulphide. The latter was weighed and then oxidized by nitric acid. The total sulphur in the precipitated sulphide of arsenic was determined by precipitating the resulting sulphuric acid by barium chloride.

The non-volatile chlorides were found to consist of silver, lead, and thallium. The amount of chloride of silver left after treatment with nitric acid and water was comparatively small; the lead was precipitated and weighed as sulphate; and the thallium was separated as sulphide by precipitation with ammonium sulphide in alkaline solution, and then converted into sulphate. The solution gave a yellow precipitate with potassium iodide, and a brilliant green colour to the Bunsen-flame, showing in the spectroscope the characteristic green line. The percentage of thallium given below is that determined by deducting the chlorides of silver and lead from the weight of the non-volatile chlorides.

Two determinations of specific gravity, made with a 3 cc. pyknometer, on 27 milligrams gave the numbers 4·6 and 4·7 respectively.

The second analysis (the result of which is given under II) was made on the other variety of hutchinsonite, which occurs in minute, deep-red needles and has a deep cherry-red streak quite distinct from the scarlet streak of the first variety.

Of this second variety of hutchinsonite a somewhat larger amount of material (about 66 milligrams) was available for analysis. The minute tufts of needles detached from the dolomite were not absolutely pure. On separating the needles under the lens a little iron-pyrites in minute crystals and small fragments of a mineral giving a black streak were seen to be present. It spite of every care to remove these impurities, it is probable that traces of them were still present in the material analysed, but it is hardly conceivable that they could be in sufficient amount to account for the lead obtained in the analysis. In this analysis the same methods were employed as in the preceding one, except that the arsenic was precipitated by magnesia mixture. The solution of the volatile chlorides contained sulphur and arsenic and a little antimony; the non-volatile chlorides included copper, besides silver, lead, and thallium.

A determination of specific gravity made with a 3 cc. pyknometer on 0·0732 gram gave the number 4·6.

The results of the two analyses are as follows:—

	I.	II.
Ag	9	2
Tl	25	18
Pb	12½	16
Cu	—	3
Fe	—	0½
As	30½	29½
Sb	—	2
S	26	26½
	103	97½

In analysis I, weight of material used = 0·0184 gram; weight of $AgCl = 0.0022$; $PbSO_4 = 0.0034$; $BaSO_4 = 0.0349$; As + S = 0·0102; $BaSO_4$ from As + S = 0·0333; $AgCl + PbCl_2 + TlCl = 0.0107$; TlCl (by diff.) = 0·0053 gram.

In analysis II, weight of material used = 0·0664 gram; weight of $AgCl = 0.0016$; $PbSO_4 = 0.0153$; $CuO = 0.0025$; $Mg_2As_2O_7 = 0.0406$; $Fe_2O_3 = 0.0005$; $SbO_4 = 0.0015$; $BaSO_4 = 0.1286$; $AgCl + PbCl_2 + CuCl_2 + Fe_2Cl_6 + TlCl = .0350$; TlCl (by diff.) = 0·0142 gram.

The most probable formula suggested by the results of the analyses is $(Tl,Ag,Cu)_2S.As_2S_3 + PbS.As_2S_3$; but, considering the small amount of material dealt with and the somewhat unsatisfactory condition as regards freedom from impurities, the formula can only be regarded as provisional until larger amounts of material are available for analysis.

That hutchinsonite may be a double salt, as suggested by the formula, is probable, since it shows so little relationship crystallographically to either smithite ($Ag_2S.As_2S_3$), lorandite ($Tl_2S.As_2S_3$), or miargyrite ($Ag_2S.Sb_2S_3$).

4. *Summary of Characters of Hutchinsonite.*

Orthorhombic; $a : b : c = 1·6343 : 1 : 0·7549$. Crystals, prismatic in habit. Cleavage, $a(100)$ good. Fracture, conchoidal. Brittle. Hardness, 1½–2. Specific gravity, 4·6. Lustre, adamantine. Colour and streak, scarlet-vermilion to deep cherry-red. Transparent to translucent. Optic axial plane parallel to $a(100)$, acute bisectrix perpendicular to $b(010)$; double refraction, negative and fairly strong. Pleochroism, weak. Composition, $(Tl,Ag,Cu)_2S.As_2S_3 + PbS.As_2S_3$.

II. Smithite.

The investigation of this species, to which Mr. Solly gave the name smithite, presented on the whole far less difficulty than was experienced

in the case of hutchinsonite. Comparatively large fragments were obtained and no ambiguity, such as arose owing to the diversity in the coloration of the latter species, was encountered. The highly perfect cleavage and the characteristic interference-figure visible through the cleavage-face in convergent, monochromatic light provided an easy and satisfactory means of discriminating the species. It was, therefore, possible to collect an amount of pure material sufficient for a trustworthy determination of the chemical composition.

1. *Morphological Characters.*

Smithite is found usually in cleavage-fragments, which are sometimes as much as 3 mm. in length and 1 mm. in thickness, and well-formed crystals are uncommon. The finest crystal which has as yet come to light is shown in fig. 5; the approximately circular contour as seen in the drawing represents a diameter of nearly 1 mm. on the actual crystal. It lies in contact with a similar, but slightly inferior, crystal on a lump of sartorite. The crystals almost imperceptibly pass into the sartorite at the back, and no sharp division can be drawn between the red and the black minerals. These crystals were almost the first of the

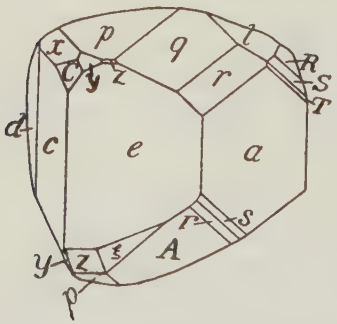

Fig. 5.

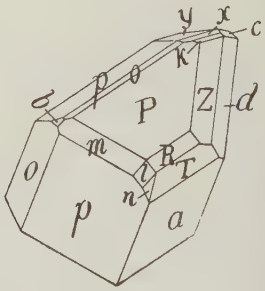

Fig. 6.

Crystals of Smithite.

red minerals to be discovered by Mr. Solly. Both were measured by him and the results of his measurements are recorded in his paper[1]. The crystal depicted in fig. 6 is much smaller and measures only 0·5 mm. in the greatest diameter. Several faces have been omitted on account of their smallness of size. The crystal was observed on a large cleavage-

[1] Loc. cit., p. 74.

fragment of smithite found in 1904, which provided the material used in the chemical analysis. The crystal is of interest for several reasons. The habit is peculiar, and the development is unusually complete; the zone [*ac*] is inconspicuous and what is to all appearance the prism is really the principal pyramid-zone [*ap*]. No fewer than eight forms are represented, none of which have been observed on any other crystal; among them are the forms with complex symbols θ (759), G (0·1·10), H (3·1·10), and β (10·0·1). The rare zone [*ab*] too is well represented.

The ordinary appearance of the crystals of smithite is suggestive of a hexagonal crystal in which the basal plane is largely developed, due to the fact that the azimuthal angle (62° 56′) between the principal zones intersecting in the prominent cleavage-face approximates to 60° so far as the eye can judge. One cleavage-fragment had on the edge an irregular arrangement of small crystals of a deeper red, which proved on examination to be hutchinsonite. Another cleavage-fragment contained a number of small, opaque needles; one of them was with difficulty isolated, and the measurements in the prism-zone, which alone were possible, are in fair agreement with those required for stibnite.

The colour of smithite is a scarlet-vermilion, exactly like that of proustite, and the powder has the same hue. On prolonged exposure to strong sunlight the colour changes to an orange-red. Smithite is lighter in colour and more transparent than is usually the case with hutchinsonite. The associated minerals are sartorite, rathite, blende, iron-pyrites, realgar, orpiment, and hutchinsonite.

The three-circle goniometer was employed for the determination of the positions of the faces on all the measured crystals, and the cleavage-face, which was always conspicuous and gave a brilliant reflexion, was selected as origin. The measurements made on the best crystals, eight in number, are summarized in table III. Altogether fifty-seven forms have been observed, of which sixteen, viz. *a*, *c*, *e*, *d*, *s*, *r*, *q*, *B*, *p*, π, *o*, *T*, *S*, *Q*, *P*, ρ, have already been recorded by Mr. Solly[1]. The constants deduced by him, viz. $a : b : c = 2{\cdot}2309 : 1 : 1{\cdot}9657$; $\beta = 101° 12\frac{1}{2}'$ ($78° 47\frac{1}{2}'$), differ little from those given below.

[1] The form given by him as ($\bar{2}12$) should be ($12\bar{2}$).

TABLE III (Smithite).

Measurements from a = (100).

$a : b : c = 2{\cdot}2206 : 1 : 1{\cdot}9570$; $\beta = 101° 12'$.

Form.	Indices.	Calculated values.		Observed Means.		Number.	Limits of Observations.	
		Azimuth.	Distance.	Azimuth.	Distance.		Azimuth.	Distance.
b	010	*	*	90° 0′	90° 0′	2	... 90° 14′	... 90°
μ	140	,,	83° 27′	,, ,,	83 38	1		
w	130	,,	81 18	,, ,,	81 37	1		
v	120	,,	77 4	,, ,,	77 18	2	... ...	77° 5′, 77
m	110	,,	65 20½	,, ,,	65 44	1		
l	320	,,	55 27	,, ,,	55 17	4	... ...	55 5 −55
n	210	,,	47 26½	,, ,,	47 16	2	... ...	46 57, 47
ν	520	,,	41 4	,, ,,	40 55	1		
J	44$\bar{1}$	82° 43′	−66 46	83 23	−65 50	1		
D	121	71 10	70 31	71 40	70 30	1		
U	61$\bar{1}$	*	−22 55	62 56	−22 52	1	62° 38′ −63 11	
T	51$\bar{1}$	,,	−27 6	,, ,,	−27 2	4	... ...	27 0 −27
S	41$\bar{1}$	,,	−32 54½	,, ,,	−32 50	4	... ...	32 48 −32
R	31$\bar{1}$	,,	−41 21	,, ,,	−41 14	2	... ...	41 13, 41
Q	21$\bar{1}$	,,	−53 58	,, ,,	−54 2	6	... ...	53 55 −54
P	11$\bar{1}$	,,	−72 19	,, ,,	−72 14	2	... ...	72 11, 72
σ	34$\bar{4}$	,,	−77 47	,, ,,	−77 56	1		
τ	233	,,	−79 40	,, ,,	−79 31	1		
ρ	122	,,	−83 28½	,, ,,	−83 24	1		
o	011	,,	84 51	,, ,,	84 50	2	... ...	84 45, 84
π	355	,,	71 27½	,, ,,	71 25	1		
p	111	,,	63 29	,, ,,	63 22½	5	... ...	63 16 −63
B	322	,,	54 53	,, ,,	54 47	3	... ...	54 45 −54
q	211	,,	47 46	,, ,,	47 34	8	... ...	47 20 −47
a	15·7·7	,,	45 59	,, ,,	45 58	2	... ...	45 56, 46
A	522	,,	41 57½	,, ,,	41 53	1		
r	311	,,	37 13	,, ,,	37 6	5	... ...	36 54 −37
s	411	,,	30 6	,, ,,	30 4	3	... ...	30 1 −30
t	511	,,	25 6½	,, ,,	25 10	1		
θ	759	47 23½	58 44½	48 13	58 46	1		
Ξ	41$\bar{3}$	33 7	−50 3	32 59	−50 26	1	32 55 −33 3	
Z	31$\bar{3}$	,, ,,	−59 35½	,, ,,	−59 35	2	... ...	59 31, 59
k	013	,, ,,	80 35	,, ,,	80 45	1		
x	113	,, ,,	67 23	,, ,,	67 24	3	... ...	67 20 −67
y	213	,, ,,	56 16½	,, ,,	56 16	4	... ...	56 14 −56
z	313	,, ,,	47 26	,, ,,	47 28	3	... ...	47 26 −47
ξ	413	,, ,,	40 32	,, ,,	40 26	2	... ...	40 21, 40

TABLE III—*continued.*

Indices.	Calculated values.		Observed Means.		Number.	Limits of Observations.	
	Azimuth.	Distance.	Azimuth.	Distance.		Azimuth.	Distance.
21$\bar{4}$	26 4	−77 17	26 20	−77 14	2	25 50, 26 50	76 50, 77 38
215	21 22½	62 34	21 15	62 40	2	21 10, 21 20	62 30, 62 50
1.1.10	11 4	79 0	11 0	78 58	2	10 45 −11 15	78 56, 79 0
1.1.10	,, ,,	65 21	,, ,,	66 0	1		
40$\bar{1}$	*	−16 27	0 0	−16 23	1		
1.0.3	,,	−17 53½	,, ,,	−17 45	1		
502	,,	−26 1	,, ,,	−25 37	1		
20$\bar{1}$	,,	−32 1	,, ,,	−31 58	1		
503	,,	−37 34½	,, ,,	−37 26	1		
403	,,	−45 0	,, ,,	−44 53	2	... ...	44 20, 45 26
.01	,,	*	,, ,,	−54 59	9	... ...	54 53 −55 6
001	,,	*	,, ,,	78 48	10	... ...	78 37 −79 0
308	,,	61 51	,, ,,	62 8	1		
02	,,	57 5	,, ,,	57 6	3	... ...	57 6 −57 6
05	,,	53 36	,, ,,	53 43	1		
01	,,	42 22	,, ,,	42 26	5	... ...	42 18 −42 35
01	,,	19 4	,, ,,	19 5	1		
01	,,	14 46	,, ,,	14 25	1		
0.1	,,	6 36	,, ,,	6 53	1		
00	,,	*	,, ,,	0 0	14		

Of the forms given above, the most prominent are a (100), e (101), (001), and d (101) in the prism-zone, and q (211), p (111), P ($\bar{1}$11), and (2$\bar{1}$1) in the principal pyramid-zone. The forms h (102), r (311), (3$\bar{1}$1), and l (320) are occasionally represented by relatively large ces; but the remainder are quite small and often very minute.

There is a highly perfect cleavage parallel to a (100), which, as has en pointed out, provides a ready means of discriminating this species om hutchinsonite and trechmannite. The glistening of the cleavage-ce readily catches the eye, and will reveal the existence of a thin i of smithite on a lead sulpharsenite, which might otherwise have caped detection.

table IV are given the calculated coordinates of the principal rms with reference to the face of symmetry, b (010), as origin.

TABLE IV (Smithite).

Calculated Coordinates of the principal forms referred to b=(010) *as origin.*

Form.	Indices.	Azimuth.	Distance.
Q	$\bar{2}11$	−32° 1½′	43° 56½′
d	$\bar{1}01$	−54 59	90 0
Z	$\bar{3}13$	,, ,,	61 53
P	$\bar{1}11$	,, ,,	31 57½
c	001	78 48	90 0
x	113	63 33	59 43
h	102	57 5	90 0
y	213	51 27	62 58½
e	101	42 22	90 0
z	313	,, ,,	66 16
p	111	,, ,,	37 10
q	211	26 37½	48 45
r	311	19 4	57 24½
a	100	0 0	90 0
l	320	,, ,,	34 33
m	110	,, ,,	24 39½
v	120	,, ,,	12 56

2. *Optical Characters.*

As in the case of hutchinsonite, very little of the violet end of the spectrum beyond the yellow is transmitted, and there is some indication of pleochroism. The lustre is adamantine.

If a cleavage-plate, which is parallel to *a* (100), be viewed in monochromatic, convergent light between crossed nicols a system of interference rings slightly out of centre may be seen; no rings are visible in white light. The figure is such as would be given by a biaxial crystal in the direction of one of the bisectrices, but no 'eyes' are visible.

even in red light. A plate was mounted on an axial-angle instrument and it was found that the centre of the figure is inclined at an angle of 21° in air, equivalent to $6\frac{1}{2}°$ in the crystal, for sodium-light, and at an angle of 13° in air, equivalent to 4° in the crystal, for red (C) light, with the normal to a (100) in the obtuse angle (100 : 00$\bar{1}$). Even when the plate is dipped into pure methylene iodide the 'eyes' are invisible for any colour, however far the plate be rotated; but the curvature of the rings increases considerably and they become nearly circular in form. It is probable, therefore, that the optic axes were only just internally reflected, in which case the angle between the optic axes within the crystal for sodium-light would be about 65°. At any rate, there seems no doubt that it is the acute bisectrix which is so nearly at right angles to a (100), and the plane of the optic axes is therefore parallel to b (010). The usual test by means of a quartz-wedge shows that the character of the double-refraction is negative.

Unfortunately, none of the crystals of smithite examined were favourably enough developed for the determination of the principal indices of refraction; indeed, it rarely happens that any zone extends completely round a crystal. Further, they are too small or too thin to permit of the grinding of artificial faces for the purpose. It was possible on the crystal shown in fig. 6 to observe the light refracted through the prism formed by faces of the forms o (011) and p (111), and the measurements of the angles of minimum deviation lead to the values 3·18 and 3·36 for sodium-light, whence is obtained 3·27 as an approximate value for the mean refractivity, slightly higher than that found for hutchinsonite.

3. *Chemical Composition.*

For the analysis of smithite much more satisfactory material was available than in the case of hutchinsonite. It consisted of a fairly large cleavage-fragment of the mineral, part of which was perfectly pure and free from inclusions. A preliminary analysis was made on about 10 milligrams of less pure material containing minute, dark, needle-like inclusions. The mineral was decomposed in chlorine and the analysis was conducted by the same methods as in the case of hutchinsonite. The result of this preliminary analysis, made on 0·0502 gram, was as follows:—Ag, 40; Pb, 1; Cu, 2; As, $25\frac{1}{2}$; S, $26\frac{1}{2}$; total, 95·0 per cent. For the second analysis, made on perfectly pure material, as much as a decigram was available. The result was as follows:—

			Atomic ratios.		Calc. for $AgAsS_2$.
Ag	...	43·9	0·407	...	43·69
As	...	28·9	0·385	...	30·36
Sb	...	0·4	—	...	—
S	...	26·0	0·812	...	25·95
		99·2			100·00

Weight of material used = 0·1076 gram; weight of AgCl = 0·0626; $BaSO_4$ = 0·2037; $Mg_2As_2O_7$ = 0·0643; SbO_2 = 0·0005 gram.

Specific gravity, as determined with a 3 cc. pyknometer on 0·1128 gram of pure material, = 4·88.

The numbers obtained agree very closely with the simple formula $AgAsS_2$ or $Ag_2S.As_2S_3$.

4. *Summary of Characters of Smithite.*

Monoclinic; $a : b : c = 2·2206 : 1 : 1·9570$; $\beta = 101° 12'$. Crystals, hexagonal in habit, tabular and occasionally modified. Cleavage, a (100), highly perfect. Fracture, conchoidal. Brittle. Hardness, $1\frac{1}{2}$–2. Specific gravity, 4·88. Lustre, adamantine. Colour and streak, scarlet-vermilion, altering to orange-red on exposure. Transparent. Optic axial plane parallel to b (010); acute bisectrix inclined at $6\frac{1}{2}°$ (Na) and 4° (Li) to normal to a (100) in the obtuse angle (100 : 00$\bar{1}$); 2E about 65°. Double refraction, negative and fairly strong. Pleochroism, weak. Mean refractive power, 3·27 approximately. Composition, $Ag_2S.As_2S_3 = AgAsS_2$.

III. Trechmannite.

Of these red minerals, by far the rarest, at the present time, is the third species, to which the name trechmannite has been assigned by Mr. Solly. In consequence, it has not been possible to carry out the investigation of its characters to the same completion as in the case of the two companion species just considered; and, moreover, so little material could be spared for analysis, that even a complete qualitative determination of the chemical composition was impracticable. As has already been stated at the beginning of this paper, the discovery of this new mineral was made by Mr. Solly on an examination of the specimen placed at his disposal by Dr. Trechmann; none of the crystals on it, however, were sufficiently well developed for a satisfactory

determination of the morphological characters. In 1904 a single good crystal (fig. 7) with dull, but plane, faces was found; in the following year (1905) a pair of brilliant crystals in nearly parallel position, the larger of which is illustrated in fig. 8, came to light; and finally, last summer Mr. Solly secured five specimens, on each of which were a few small, well-developed crystals.

The satisfactory discrimination of trechmannite from the lighter-coloured variety of hutchinsonite requires the crystal to have a sufficient number of faces for the recognition on goniometrical examination of some characteristic angle. If, however, the crystal be intimately associated with tennantite ('binnite') it is in all probability trechmannite.

1. *Morphological Characters.*

Trechmannite has a remarkable predilection for the black and metallic-looking tennantite ('binnite') characteristic of this locality, and, indeed, all the good crystals which have been observed were found springing from this mineral. The crystals are always small, and, as will be pointed out in further detail below, they are frequently corroded in parts.

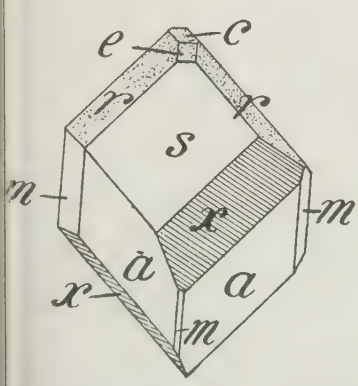

Fig. 7.

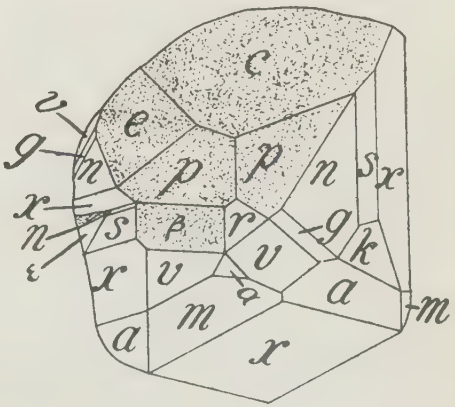

Fig. 8.

Crystals of Trechmannite.

For the determination of the morphological constants the measurements made on the five best crystals observed were alone utilized.

Crystal 1 (fig. 7) was found by Mr. Solly[1] and has already been described by him. Part of the crystal of tennantite ('binnite') on which it was found had to be cut away in order to complete the measurements. It is the largest crystal as yet found and measures 1 mm. in the greatest diameter; the remaining crystals do not exceed 0·7 mm. All the faces are dull, but mostly give distinct reflexions of the object-slit with the exception of those (c, e, and r) stippled in the drawing, which were so much corroded that no measurements were possible. The edges between the faces are, however, so distinct as to leave no doubt regarding the identification of the faces. Each face of the rhombohedron of the third order, x, is striated parallel to its intersection with that face of the contiguous form which makes the smaller angle with it.

Crystal 2 (fig. 8) is the larger of a pair in nearly parallel position, which were found in 1905 and have likewise been measured by Mr. Solly.[2] The second individual lies to the right, when viewed as depicted in the figure. Here again, certain faces (c, e, p, and β) are corroded, and no trustworthy measurements of them were possible. It is curious that the faces closely adjoining are bright, even up to the edge or edges separating them from those corroded. On the left the crystal is broken and certain faces (x and n) are repeated on either side; a re-entrant angle is, of course, formed where the faces n and x on opposite sides meet. The crystal is most irregularly developed and the prism is by no means the most conspicuous zone.

Crystal 3 (fig. 9) was found last summer; a small crystal of iron-pyrites is partially embedded in it at the back. Again, certain faces (p, r, and η) are corroded, and in this case the edges bounding them are indistinct, so that the identification of them is uncertain. The crystal is, moreover, broken at the top. The prism-zone is unusually conspicuous, and the faces of the form a are striated parallel to the edge of the prominent zone [$azxsn$]. These striae, together with the considerable development of faces below as well as above the prism-zone, reveal clearly the nature of the symmetry, to which we recur below.

Crystal 4 (fig. 10) also was found last summer. It surpasses all that have yet been observed as regards the brilliancy of the reflexions and the number of the faces present; in all thirty-nine distinct faces were observed, many of which are too minute to be reproduced in the

[1] Loc. cit., p. 75.
[2] Loc. cit., p. 189.

drawing. There are no signs of corrosion. The stippling in the figure represents a gap in the crystal, on both sides of which appears a face of the form *c*.

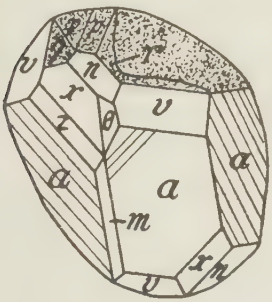

Fig. 9.

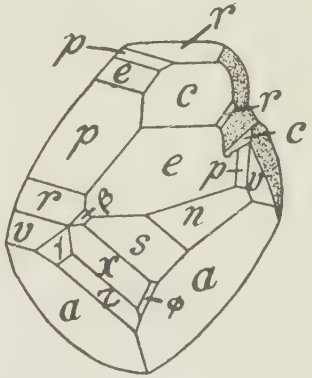

Fig. 10.

Crystals of Trechmannite.

Crystal 5, likewise found last summer, is very imperfect and possesses few faces other than those in the prism-zone. The faces of the form *a* are striated parallel to the prism-edge.

The illustrations represent as faithfully as possible the actual crystals.

The colour of trechmannite is a scarlet-vermilion, and that of its streak is the same. There is a good cleavage parallel to *r* (100), and Mr. Solly[1] has noticed another perpendicular to the edge of the prism-zone. The associated minerals are, in addition to tennantite ('binnite'), heligmannite, blende, iron-pyrites, and a colourless to light-greenish mica (fuchsite).

Trechmannite belongs to the hexagonal-alternating, or diplohedral, class of the rhombohedral system[2], which includes such important species as ilmenite and phenacite. A study of fig. 9 shows clearly that the crystal possesses a centre of symmetry and a trigonal axis, which together are equivalent to a hexagonal-alternating axis, but is devoid of planes of symmetry and digonal axes. The zone [*azxsn*] is always prominent, and the form *x* is one of the most conspicuous (cf. figs. 7 and 8).

[1] Loc. cit., p. 75.

[2] The symmetry was at first incorrectly stated (Nature, 1905, vol. lxxi, p. 574) to be that of quartz on the examination of an incompletely developed crystal, and was so given by Mr. Solly, loc. cit., p. 190.

TABLE V (Trechmannite).

Measurements from c = (111) = (0001).

Rhombohedral, diplohedral; $a:c = 1:0{\cdot}6530$.

Form.	Indices.		Calculated Values.		Observed Means.		Number.	Limits of Observations.	
	Rhombohedral.	Hexagonal.	Azimuth.	Distance.	Azimuth.	Distance.		Azimuth.	Distance.
			... ...	0° 0′	... ...	... ...	4		
c	111	0001	0° 0′	90 0	0° 0′	90° 0′	11		
m	$\bar{2}11$	$10\bar{1}0$			10 11	,, ,,	1		
F	$\bar{3}21$	$14\bar{5}0$	10 53½	,, ,,	13 23	,, ,,	1		
d	$\bar{7}25$	$13\bar{4}0$	13 54	,, ,,	16 10	,, ,,	3	16° 0′ – 16° 19′	
D	$\bar{4}13$	$25\bar{7}0$	16 6	,, ,,	30 0	,, ,,	13	30 15	
a	$\bar{1}01$	$11\bar{2}0$	30 0	,, ,,	0 0	9 0	1		
H	122	$10\bar{1}5$	0 0	8 34½		12 10	1		
G	133	$20\bar{2}7$	,, ,,	12 9½	,, ,,	20 41	3	... ...	20° 36′ – 20° 48′
e	011	$10\bar{1}2$	,, ,,	20 39½	,, ,,	56 28½	11	... ...	56 24 – 56 37
s	$\bar{1}11$	$20\bar{2}1$	,, ,,	56 33	,, ,,	75 27	1		
φ	$\bar{3}22$	$50\bar{5}1$	,, ,,	75 9	,, ,,	37 2	5	... ...	36 57 – 37 11
r	100	$10\bar{1}1$	,, ,,	37 1	,, ,,	71 38½	2	... ...	71 37, 71 40
a	$3\bar{1}\bar{1}$	$40\bar{4}1$	,, ,,	71 39½	,, ,,		1		
θ	$\bar{1}7{\cdot}12{\cdot}14$	$2{\cdot}29{\cdot}3\bar{1}{\cdot}9$	3 19	68 20	3 8	68 15	1		
k	765	$1{\cdot}12{\cdot}\bar{1}3{\cdot}4$	3 58½	67 3	4 1	66 55	1		
λ	656	$1{\cdot}11{\cdot}\bar{1}2{\cdot}5$	4 18½	60 6	4 38	60 19	1		
n	$\bar{2}32$	$14\bar{5}3$	10 53½	49 2	10 59	49 3	9	10 37 – 11 4	48 58 – 49 9
x	$\bar{2}12$	$13\bar{4}1$	13 54	69 48½	13 58	69 50	14	13 48 – 14 9	69 45 – 69 59
V	531	$26\bar{8}1$	,, ,,	79 35	13 57	79 32	1		
δ	$\bar{6}37$	$4{\cdot}9{\cdot}\bar{1}3{\cdot}4$	17 29	65 18	17 40	65 13	1		
ϵ	$8{\cdot}5{\cdot}11$	$6{\cdot}13{\cdot}\bar{1}9{\cdot}8$	18 9	57 42	18 13	57 44	1		
	$2\bar{1}0$	$12\bar{3}1$	19 6½	63 22½	19 8	63 25	13	18 58 – 19 15	63 16 – 63 36

z	313	2461	19 6½	75 56	19 7	75 56	4	18 54 – 19 12	75 40 – 76 10
q	325	3584	21 47	52 50½	21 56	52 55½	2	21 53, 21 59	52 50, 53 1
ζ	11.10.1	3581	,, ,,	79 16	21 39	79 23½	2	21 38, 21 40	79 20, 79 27
η	124	2355	23 25	33 19	23 30	33 10	1		
β	411	2354	,, ,,	39 24½	23 14	39 22	1		
χ	430	3471	25 17	77 42					
γ	541	4592	26 19½	71 14½	26 9	71 40	1		
p	012	1123	30 0	23 31½	30 0	23 40	4	30 4	23 29 – 23 55

TABLE VI (Trechmannite.)

Measurements from $a = (\bar{1}01) = (10\bar{1}1)$.

Form.	Indices.		Calculated Values.		Observed Means.		Number.	Limits of Observations.	
	Rhombohedral.	Hexagonal.	Azimuth.	Distance.	Azimuth.	Distance.		Azimuth.	Distance.
z	313	24$\bar{6}$1	*	17° 43½′	52° 59′	17° 39½′	5	52° 52′ – 53° 4′	17° 33′ – 17° 40′
x	212	13$\bar{4}$1	,,	25 37	,, ,,	25 33	12	... ...	25 3 – 25 47
s	111	20$\bar{2}$1	,,	43 48	,, ,,	43 44	12	... ...	43 11 – 43 58
n	232	1453	,,	55 11	,, ,,	55 9	5	... ...	55 0 – 55 20
r	010	10$\bar{1}$1	,,	*	,, ,,	90 0	5	... ...	90 5
c	111	0001	90° 0′	90 0					
χ	304	3471	69 20½	13 9¼	69 18½	12 52½	2	69 7 – 69 29	12 45, 13 0
v	102	12$\bar{3}$1	,, ,,	28 37	,, ,,	28 36	4	... ...	28 30 – 28 43
r	001	10$\bar{1}$1	,, ,,	58 34½	,, ,,	58 32	4	... ...	58 29 – 58 38
p	102	11$\bar{2}$3	,, ,,	78 29	,, ,,	78 24	4	... ...	78 15 – 78 33
e	101	10$\bar{1}$2	,, ,,	*	,, ,,	90 0	2	... ...	90 3

All four crystals were measured on the three-circle goniometer from the face $c=(111)=(0001)$ as origin, and in the three cases where this face was corroded the crystals were set up by means of the prism-zone. In table V are given the means of the observed values and the calculated values of the coordinates. The latter values have been computed from the mean of the azimuths of the prominent zone [*azxsn*], viz. 52° 59′ (see table VI). The axial ratio thus determined, $a:c=1:0{\cdot}6530$, differs little from that deduced by Mr. Solly from his measurements, viz. $a:c=1:0{\cdot}6556$.

In all, thirty forms have been observed, of which seven, viz. *c*, *r*, *x*, *z*, *a*, *m*, *d*, were noted by Mr. Solly; the form $f=\{32\bar{5}\}=\{17\bar{8}0\}$ recorded by him has not been noticed.

Further, on all four crystals, measurements were made of the faces in the two prominent zones intersecting in $a=(\bar{1}01)=(11\bar{2}0)$ from this pole as origin, and the means of the observations together with the corresponding calculated values are given in table VI.

The characters of the various forms are as follows:—

$c=\{111\}=\{0001\}$ usually small and frequently corroded.

$m=\{\bar{2}11\}=\{10\bar{1}0\}$ common, but small.

$a=\{\bar{1}01\}=\{11\bar{2}0\}$ common and large; striated on one crystal parallel to the edge of the zone [*azxsn*] and on another parallel to the prism-edge.

$r=\{100\}=\{10\bar{1}1\}$ common, but small; sometimes corroded: a cleavage parallel to it.

$e=\{011\}=\{10\bar{1}2\}$ small: sometimes corroded.

$p=\pi\{012\}=\{11\bar{2}3\}$ not common, but occasionally large: sometimes corroded: the companion form $p_1=\pi\{021\}$ is also present.

$v=\pi\{2\bar{1}0\}=\{12\bar{3}1\}$ common, but small: the companion form $v_1=\pi\{20\bar{1}\}$ is also present.

$x=\pi\{\bar{2}12\}=\{13\bar{4}1\}$ common, and often very prominent: sometimes striated parallel to the intersection with the nearest face of the form *m*.

$z=\pi\{\bar{3}13\}=\{24\bar{6}1\}$ common, but small.

$n=\pi\{\bar{2}32\}=\{14\bar{5}3\}$ common, and fairly large.

The remaining forms were in all cases rare: on crystal 2 (fig. 8) $g=\pi\{\bar{3}25\}$ is represented by two faces, $k=\pi\{\bar{7}65\}$ by one, $\alpha=\pi\{3\bar{1}\bar{1}\}$ by two, $\beta=\pi\{4\bar{1}1\}$ by one corroded, and $\epsilon=\pi\{\bar{8}{\cdot}5{\cdot}11\}$ by one, all of which faces are quite distinct though small; $\theta=\pi\{\bar{1}\bar{7}{\cdot}12{\cdot}14\}$ appears as a definite face on crystal 3 (fig. 9); one of the corroded faces probably belongs to the

form η, but for reasons given above there is some uncertainty. $\beta=\pi\{4\bar{1}1\}$ and $\gamma=\pi\{5\bar{4}1\}$ are each represented by one small, but distinct face on crystal 4 (fig. 10). Finally $V=\pi\{\bar{5}31\}$ and $\eta=\pi\{\bar{1}24\}$ are each represented by one small, but distinct face on crystal 5. The outstanding forms appeared as most minute faces. $\chi=\pi\{4\bar{3}0\}$ gave so faint a reflexion that approximate measurements in the zone [*avre*] alone were possible (see table VI).

2. *Optical Characters.*

As in the case of the previous species, very little above the red end of the spectrum is transmitted, and there is again some faint indication of pleochroism. The lustre is adamantine.

None of the crystals observed were suitably shaped for a determination of the optical constants, and the information obtained is very meagre. The mineral is highly refracting. On crushing up a small crystal, a splinter was seen which showed when viewed in convergent light between crossed nicols an indistinct uniaxial figure with negative double refraction.

3. *Chemical Composition.*

Qualitative tests made on a small fragment indicated the presence of silver and arsenic, and the absence of thallium. We may reasonably assume, therefore, that trechmannite is a sulpharsenite of silver.

4. *Summary of Characters of Trechmannite.*

Rhombohedral, diplohedral; $a:c=1:0{\cdot}6530$. Crystals, prismatic in habit often irregular; sometimes corroded in parts. Cleavage, *r* good, *c* distinct. Fracture, conchoidal. Brittle. Hardness, $1\frac{1}{2}$–2. Lustre, adamantine. Colour and streak, scarlet-vermilion. Transparent to translucent. Double refraction, fairly strong; negative. Pleochroism, weak. Composition, probably a sulpharsenite of silver.

The formula found for smithite at once suggests that some obvious relation should subsist between its morphological characters and those of miargyrite, the corresponding sulphantimonite, such as obtains in the case of proustite and pyrargyrite; but, though both smithite and miargyrite are monoclinic in symmetry, there is no accord between the interfacial angles. Again, hutchinsonite contains thallium, but its morphological characters bear no resemblance to those of lorandite, the sulpharsenite of thallium. Finally, all three of the red minerals discussed in this paper differ completely from one another in their crystalline characters.

Notes on some Bolivian minerals (*Jamesonite, Andorite, Cassiterite, Tourmaline, &c.*).

By L. J. Spencer, M.A., F.G.S.

With chemical analyses by G. T. Prior, M.A., D.Sc., F.G.S.
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[Read November 13, 1906.]

Contents.

1. Analysis of crystallized Jamesonite.
2. Semseyite from Oruro.
3. New crystal-forms on Andorite: Systematic position of Andorite.
4. Chalcostibite from Oruro.
5. Augelite from Oruro and Tatasi.
6. New crystal-forms on Vivianite.
7. Tetrahedrite from Pulacayo mine, Huanchaca.
8. Regular grouping of Stannite and Tetrahedrite.
9. Axial ratios and analysis of Valentinite.
10. Cassiterite.
11. Tourmaline and Tourmaline-Hornfels from Tasna.
12. Fluorite.
13. Apatite.
14. Cupriferous Miargyrite from Tatasi.
15. Miargyrite from Aullagas.
16. Jarosite from Chocaya, Dept. Potosi.
17. Chalybite from Chorolque and Tatasi.
18. Enargite from Chorolque.

During the last twelve years I have communicated to this Society, often in collaboration with Dr. G. T. Prior, several papers descriptive of Bolivian minerals. These papers have dealt primarily with the species augelite, andorite, argyrodite, stannite, and chalcostibite, though many others have been examined and in some cases incidentally mentioned. The latter, as being of lesser general interest, or as not having led to sufficiently important results for separate publication, are now collected together in the present notes.

The material available for examination has been acquired for the British Museum collection from various sources, and mainly during the last few years. Special mention may be made of several lots of specimens sent, at various times since 1894, for examination, and presented to the Museum by my friend Mr. Malcolm Roberts, A.R.S.M., a mine manager in Bolivia. Another collection, which may be specially mentioned, was brought from Bolivia by Sir Martin Conway, and presented by him in 1899 to the British Museum. A few choice specimens, notably a mass of pyrargyrite with crystals of argyrodite from Colquechaca, and a large mamillated mass of native copper coated with native silver from the Cobrizos mine at San Cristobal in province Nor-Lipez, have been presented by Señor F. Avelino Aramayo, formerly the Bolivian Minister in London. Thanks are also due to Mr. Thomas J. Hooper, General Manager to the Compañia Minera de Oruro, for a very large and magnificent specimen of andorite. Still more recently, several Bolivian specimens have been selected from the private collection of the late Theodor Hohmann (1843–1897), a mining engineer in Chili[1].

The specimens sent by Mr. Roberts are mainly from the silver mines at Tatasi and Portugalete in the province Sud-Chichas, and from the tin and bismuth mines at Tasna in province Nor-Chichas, department Potosi. From his own observation and from my notes on the specimens, Mr. Roberts[2] has published a brief account of the mineral-species which he has found at the former locality.

Sir Martin Conway's specimens are mostly from the silver and tin mines at Oruro, and from a tin and bismuth mine on the mountain of Huaina Potosi, near La Paz. A description of the twenty-three mineral-species represented in this collection of forty-six specimens has already been given[3] in some detail in the narrative of Sir Martin Conway's expedition; from this source such points as appear to be of general mineralogical interest are incorporated in the present notes.

[1] A brief description of this collection has been given by R. Pöhlmann, 'Die Mineralien-Sammlung des † Theodor Hohmann.' Verh. Deutsch. wiss. Ver. Santiago de Chile, 1899, vol. iv, pp. 75–86.

[2] M. Roberts, 'Minerals found in the silver lodes of Tatasi and Portugalete, Bolivia.' Trans. Inst. Mining and Metallurgy, London, 1899, vol. vii, pp. 91–3.

[3] L. J. Spencer, 'A description of the mineral specimens brought from Bolivia by Sir W. Martin Conway.' Pp. 343-66 in Sir Martin Conway, 'The Bolivian Andes, a record of climbing and exploration in the Cordillera Real in the years 1898 and 1900.' Harper & Brothers, London and New York, 1901. The appendix of this volume also includes notes on other natural history specimens—the rock specimens were described by Professor T. G. Bonney (pp. 366–86)—but unfortunately there are no indications on the title-page nor

1. Analysis of crystallized Jamesonite[1].

The specimens (Brit. Mus. nos. 80934, 83057, 83058) to be described are from the Cerro de Ubina[2], situated to the east of Huanchaca, and in the province Porco of the department Potosi. Tufts of jamesonite needles are disposed in the spaces between iron-pyrites crystals, which are present as veins in the massive, fibrous and radiating jamesonite forming the bulk of specimens. These veins of iron-pyrites consist of a granular aggregate of crystals interfering with each other's growth, and are of two kinds. The larger veins consist of fairly large and bright octahedra with small planes of the cube and pentagonal dodecahedron e {210} ; it is in cavities between these crystals of iron-pyrites that most of the jamesonite needles are developed. The other veins are much narrower and consist of small cubes of iron-pyrites with small planes of the octahedron and e {210}. Imbedded in the massive jamesonite are patches of argentiferous tetrahedrite, and in cavities one or two minute crystals of native sulphur.

The needles of jamesonite reach a length of $\frac{1}{2}$ cm. and a thickness of $\frac{1}{2}$ mm.; they are deeply striated parallel to their length, and are usually closely aggregated. They are iron-black with a bright metallic lustre, and sometimes a slight iridescent tarnish. The streak is black and dull or in part shining; the hardness is $2\frac{1}{2}$. The needles are very brittle; they do not bend, but break along surfaces of good cleavage[3] perpendicular to their length.

Nineteen crystals were placed on the goniometer, but no really good measurements were obtained. The predominating form is the prism m {110}, and the needles have a rhomb-shaped cross-section; though sometimes one pair of parallel prism-faces is more largely developed and the crystals are then lath-shaped. Narrow faces of the forms n {120}, b {010}, and a {100} were also sometimes observed, but no terminal planes.

in the index of their existence. Figs. 1, 2, 3, and 10 in the present paper are reproduced from Sir Martin Conway's book, the electrotypes having been kindly supplied by the publishers.

[1] Compare this vol., p. 207.

[2] This occurrence has already been mentioned by A. Frenzel (Neues Jahrb. Min., 1893, vol. ii, p. 126). Here the locality is given incorrectly as 'Cerro de Uleina'.

[3] The statement of the cleavages of jamesonite given in the textbooks dates back to F. Mohs (1824). The basal cleavage, c(001), though good, can scarcely be described as perfect, and the others, m(110) and b(010), probably do not exist. The latter were not to be observed on any of the jamesonites I have examined; any apparent cleavage in these directions can be explained by the parallel aggregation of the acicular crystals.

		Limits.	No. of edges.	Mean.	Calcd.
mm''' =	110 : 1$\bar{1}$0	{ 78° 10′ – 79° 1′	4 (best)	78° 39′ }	78° 38′
		{ 77° 32 – 81°	23 (all)	79 1 }	
mm' =	110 : $\bar{1}$10	{ 101° 10 – 102° 6′	4 (best)	101 23 }	101 22
		{ 100° – 103°	21 (all)	101 16 }	
mn =	110 : 120	17° – 22°	4	19½°	19 17
mb =	110 : 010	49° – 51½°	5	50 24	50 41
$a : c$ (cleavage)		85° – 94° 52′	14	89 49	90 0

The means, 78° 39′ and 78° 37′ (=180°–101° 23′) of the best readings, give the value for $mm''' = 110 : 1\bar{1}0$ as 78° 38′, which agrees closely with Haidinger's determination[1] of 78° 40′ on needles of hamesonite from Cornwall. The axial ratio corresponding with this angle, 78° 38′, is $a : b = 1 : 0{\cdot}819$.

Two lots of material were collected for quantitative analysis. One lot consisted of isolated needles, many of which had been measured on the goniometer, together with some aggregates of needles taken from the cavities between the iron-pyrites crystals. The other lot was of massive material consisting of a more or less parallel aggregate of fibres, and showing a good end-cleavage. When examined under the microscope no impurities, such as iron-pyrites, could be detected. The method of analysis was the same as that previously adopted for andorite[2], and the following results, I for the crystals and II for the massive material, were obtained by Dr. G. T. Prior :—

	I.	Atomic ratios.			II.	Atomic ratios.		
S ...	20·52	0·6447	17·85		21·37	0·6714	18·50	
Sb ...	34·53	0·2889	8·00		34·70	0·2903	8·00	
Pb ...	41·18	0·2005	5·55		40·08	0·1952	5·38	
Fe ...	2·76	0·0496	1·37	7·03	2·79	0·0502	1·38	6·88
Cu ...	0·26	0·0041	0·11		0·22	0·0035	0·09	
Ag ...	0·01	0·0001	—		0·13	0·0012	0·03	
	99·26				99·29			
Sp. gr.	5·519				5·546			
Weight used	0·3932 gram				0·8997 gram			

[1] English translation of F. Mohs's 'Treatise of Mineralogy', Edinburgh, 1825, vol. iii, p. 26; Edinburgh Journ. Sci., 1825, vol. ii, p. 374. The manuscript catalogue of the Allan collection, now in the British Museum, gives, under No. 824, this angle as 78° 30′, the entry referring to acicular Cornish crystals. The axial ratio corresponding with Haidinger's angle is erroneously given in most textbooks as $a : b = 1 : 0{\cdot}915$.

[2] Min. Mag., 1897, vol. xi, p. 290.

The second of these analyses is the more reliable: in the first the lead sulphate included a little basic iron sulphate, and there may possibly have been a slight loss of sulphur.

These analyses do not lead to any simple formula. They correspond fairly closely with $7(Pb\frac{4}{5}, Fe\frac{1}{5})\,S.4Sb_2S_3 = R_7''Sb_8S_{19}$, the calculated percentage composition of which is given below :—

	$7(Pb_{4/5},Fe_{1/5})S.$ $4Sb_2S_3$.	$4PbS.$ $3Sb_2S_3$.	$3PbS.$ $2Sb_2S_3$.	$7PbS.$ $4Sb_2S_3$.	$2PbS.$ Sb_2S_3.
S ...	21·68	21·20	20·75	20·17	19·68
Sb ...	34·29	36·73	34·63	31·89	29·55
Pb ...	41·24	42·07	44·62	47·94	50·77
Fe ...	2·79	—	—	—	—
	100·00	100·00	100·00	100·00	100·00

The large amount of iron, which presents a difficulty in deducing a satisfactory formula, is not present as iron-pyrites, as the mode of occurrence of the mineral might suggest, since the amount of sulphur shown in the analyses is scarcely sufficient even for monosulphide. The atomic amount of sulphur required for Sb_2S_3, PbS, FeS, and CuS is 0·6855 in the second analysis, whilst the amount found is 0·6714. If the iron and copper are left out of account, the formula becomes $4PbS.3Sb_2S_3 = Pb_4Sb_6S_{13}$. As shown also by earlier analyses, quoted below, the iron appears, however, to be present in all cases to the amount of 2 to 3 per cent.

The observations recorded above were made in 1897, and their publication has been delayed in the hope of other material being found which would help to decide the question of the chemical formula of jamesonite, but, as yet, the material here described is the best available.

Several analyses have been published under the name jamesonite; but it must be remembered that many of these have been made on impure, massive material and ores, solely with the object of giving a specific mineralogical name; and that, in some cases, to make the results agree with the textbook formula, $2PbS.Sb_2S_3$, certain amounts of impurities (iron-pyrites, galena, stibnite) have been assumed to be present and have been deducted. Only those analyses which have been made on material known to be jamesonite by the presence of the basal cleavage can be of any value in deducing a formula for this mineral: such analyses are collected together below.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
S	22·15	22·53	[23·01]	21·78	21·52	20·86	21·35	21·75
Sb	34·40	34·90	33·47	32·62	33·03	31·94	not det.	32·00
Pb	40·75	39·45	40·35	39·97	40·13	42·79	40·47	39·05
Fe	2·30	2·65	2·96	3·63	not det.	2·83	2·68	2·00
Cu	0·13	0·19	0·21	—	—	1·01	0·50	3·45
Zn	—	—	—	0·42	0·36	1·84	5·82	0·62
	99·73	99·72	100·00	99·48[1]	—	101·27	—	100·41[2]
Sp. gr.	—	—	—	5·616		5·478–5719		5·54

I–III. H. Rose (Ann. Chem. Phys. (Poggendorff), 1826, vol. viii, p. 100; 1829, vol. xv, p. 470). Cornwall.

IV and V. F. Schaffgotsch (ibid., 1836, vol. xxxviii, p. 403). Valencia de Alcantara, Spain. V, the mean of three partial analyses.

VI and VII. C. Rammelsberg (C. Rammelsberg and C. Zincken, ibid., 1849, vol. lxxvii, p. 242). Selkethal, Harz. Different figures are given in Rammelsberg's Min.-Chem., 1860, p. 71; 1875, p. 92.

VIII. M. Siewert (A. W. Stelzner, Min. Petr. Mitt. (Tschermak), 1873, p. 247). Sierra de los Angulos, Argentina.

These, then, are the only analyses that can be given for what is rtainly known to be jamesonite, and one of the analyses now published he only one that has been made on measured crystals of this mineral. Rose's analyses show a slight excess[3] of sulphur over that required RS and Sb_2S_3; he consequently deducted the iron as iron-pyrites l deduced the formula $3PbS.2Sb_2S_3$. Schaffgotsch, to make his lyses agree with this formula, had to deduct $8\frac{1}{2}$ per cent. of urities (ZnS, Bi_2S_3, FeS); there being no excess of sulphur, the iron s assumed to be present as pyrrhotite. Rammelsberg deducted from analysis (VI) FeS_2, ZnS, and 6 per cent. of Sb_2S_3, and gave formula $2PbS.Sb_2S_3$. Stelzner, although he mentions that the terial analysed was apparently pure, also deducted iron (as ckel, iron-pyrites, and copper-pyrites), and deduced the formula $bS.AgS.CuS.26Sb_2S_3$.

ll these analyses show the presence of about 2 to 3 per cent. of iron,

[1] Including Bi 1·06.

[2] Including Ag 1·34, As 0·20.

[3] The excess is, however, not sufficient for iron-pyrites.

and taking this into account, they agree fairly well with the formula $7(Pb\frac{4}{5}, Fe\frac{1}{5})S.4Sb_2S_3$, suggested above.

Sulphantimonites of lead are of frequent occurrence in Bolivia and have often been referred to jamesonite, but only rarely have they been definitely determined to belong to this species. In the account of Sir Martin Conway's collection I have described [1] specimens of crystallized jamesonite from Oruro, Bolivia; these were determined by measurement of the prism-angle (about 79°) and by the presence of a good basal cleavage. Other specimens, previously referred to zinckenite [2], have since been shown by these characters to be jamesonite: they are from Machacamarca near Potosi and from the Socavon de la Virgen at Oruro.

2. Semseyite from Oruro.

The specimen here described was sent to me by the Foote Mineral Company, of Philadelphia, for determination. The crystals of semseyite are iron-black in colour and have a bright metallic lustre. They are aggregated in rosette-like groups, so that the individual crystals, which reach to 5 mm. across, are not very distinctly developed. The faces of the twisted crystals are so curved and irregular, with step-like and drusy growths, that it was impossible to obtain any reliable measurements of the angles between them. In general habit and appearance, however, the crystals are exactly like those of plagionite and semseyite from Wolfsberg in the Harz. The basal plane $c\{001\}$ and the pyramid $n\{111\}$ can be distinguished, and parallel to the faces of the latter there are good cleavages. Measurement of several of the most likely crystals gave results varying between 40° and 45° for the angle between c and n. These measurements are not sufficient to distinguish between plagionite and semseyite, since in the former $cn = 41°8'$ and in the latter $cn = 46°35'$ [3].

In order to determine to which member (plagionite, heteromorphite or semseyite) of the plagionite group of minerals the crystals belong, it therefore became necessary to determine their specific gravity and the percentage of lead they contain. A small amount (0·16 gram) of the crystallized material was collected, and was analysed by Dr. G. T. Prior with the following results:—

[1] Loc. cit., p. 359.
[2] Min. Mag., 1895, vol. xi, p. 23; 1897, vol. xi, p. 299.
[3] Min. Mag., 1899, vol. xii, p. 55.

		Atomic ratios.
Pb . . .	52·9 . . .	0·256
Ag . . .	1·6 . . .	0·015
Sb . . .	24·8 . . .	0·206
S . . .	18·7 . . .	0·583
	98·0	
Sp. gr. . .	5·82	

These results point conclusively to semseyite[1]. The presence of silver is noteworthy, since this element has not previously been detected in minerals of the plagionite group. It is possible, however, that the silver may be present as andorite intermixed with the semseyite, although no andorite could be detected on the specimen. Another point brought out by the analysis is that the mineral is rather more basic than the two semseyites previously analysed: here, $(Pb, Ag_2) : Sb = 1{\cdot}28 : 1$; whilst in semseyite from Hungary and the Harz, $Pb : Sb = 1{\cdot}15 : 1$ and $1{\cdot}05 : 1$ respectively.

The matrix of the specimen consists of another species of sulphantimonite of lead, the structure of which is fibrous. The compact aggregation of fibres, which are either radially or confusedly arranged, is mixed with some massive iron-pyrites and a little kaolin. On the free surface of the specimen the fibres have the form of delicate, flexible hairs, which can be bent without being broken, and are therefore *plumosite*[2]. The surface of this felted mass of plumosite needles is curiously marked with smooth, concave depressions, rather suggesting that the mineral had been partly dissolved. The semseyite crystals occur only on this surface and are partly embedded in the feathery plumosite. With them is a little galena, which often forms the nucleus of the rosettes of semseyite crystals.

Although sulphantimonites of lead are of common occurrence in Bolivia, they appear to belong usually to the fibrous, orthorhombic species, especially jamesonite and plumosite; and none of the monoclinic species of the plagionite group have been hitherto determined from this region. It is possible that one or more of the eight varieties of 'antimonial galena' mentioned by D. Forbes[3] from the department of La Paz may belong to the plagionite group, but his descriptions are too brief to enable one to judge of this.

[1] Compare the table of analyses and sp. gr. given in Min. Mag., vol. xii, p. 65.

[2] Compare this vol., p. 207.

[3] Phil. Mag., 1865, ser. 4, vol. xxix, p. 10. In an earlier paper (Quart. Journ. Geol. Soc., 1861, vol. xvii, p. 61) Forbes gives the name plagionite in a list of minerals occurring in the Bolivian mineral-veins.

Semseyite has previously been recorded only from Felsöbánya and Rodna in Hungary and from Wolfsberg in the Harz.

3. New crystal-forms on Andorite[1].

Andorite is, at present, known from only two localities, namely, Felsöbánya in Hungary and Oruro in Bolivia. At the latter it seems to be rather plentiful, and there are now several specimens representing this occurrence in the British Museum collection. Crystals were detected on four of the specimens from Oruro presented by Sir Martin Conway; and the following description is based mainly on that specimen on which the best crystals of stannite[2] were found.

This specimen (Brit. Mus. no. 84686), from the San José mine at Oruro, consists of groups of radiating, prismatic crystals of mispickel, encrusted with crystals of andorite, stannite, and iron-pyrites. The bright crystals of andorite are sometimes doubly terminated, and the largest is about 4 mm. long. In habit they are somewhat tabular parallel to the macropinacoid $a\{100\}$. Pyramids and domes are numerous, but are very irregularly developed, so that the crystals are usually distorted and unsymmetrical in appearance. In figs. 1 and 2 the crystals are idealized by drawing all the faces of the same form of equal size.

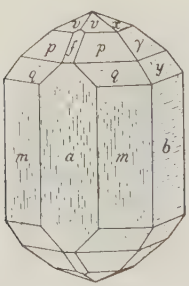


Fig. 1.

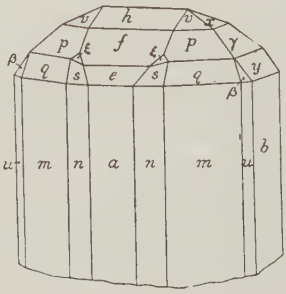


Fig. 2.

Andorite from Oruro, Bolivia.

A conspicuous feature of the crystals is the deep striation of all the faces (fig. 1); in some zones the striations are often so deep and numerous as to render the crystal almost unsuitable for measurement. The pyramids, domes, the brachypinacoid $b\{010\}$, and the prisms $u\{130\}$, $y\{250\}$, and $k\{120\}$ are all striated horizontally; the macro-

[1] Compare Min. Mag., 1897, vol. xi, p. 286.

[2] Min. Mag., 1901, vol. xiii, p. 55.

pinacoid $a\{100\}$ and the remaining prisms are striated vertically, with a few horizontal striae, especially on $a\{100\}$, giving rise to rectangular markings. On the goniometer, these striated zones give continuous bands of reflected images, limited, however, between certain points: in the prism-zone between $a(100)$ and $l(230)$; in the macrodome-zone between $a(100)$ and $h(102)$; in the brachydome-zone between $b(010)$ and $x(011)$ or $w(035)$; and in the several pyramid-zones $[hk0, 001]$ the bands are limited between the zones [100, 010] and [102, 010]. As the summit of a crystal is approached, the striations become less numerous and the bands of reflected light much fainter. The pyramid-zones showing such bands of light are:—[310, 001], [210, 001], [110, 001], [230, 001], [120, 001], and [130, 001]; of these it may be remarked that no pyramidal faces have yet been recorded in the zone [230, 001].

Three crystals were measured on the goniometer, and the following thirty-five forms noted:—

Pinacoids:	$a\{100\}$	$b\{010\}$	$c\{001\}$.			
Prisms:	$n\{210\}$	$m\{110\}$	$l\{230\}$	$k\{120\}$	$g\{250\}$	$u\{130\}$.
Macrodomes:	$h\{102\}$	$\sigma\{203\}$	$f\{101\}$	$e\{302\}$.		
Brachydomes:	$w\{035\}$	$x\{011\}$	$\gamma\{021\}$	$y\{031\}$	$\eta\{041\}$.	
Pyramids:	$\xi\{312\}$	$s\{211\}$	$A\{321\}$	$v\{112\}$	$C\{243\}$?	$\omega\{132\}$
				$\chi\{223\}$	$\delta\{364\}$	$\beta\{131\}$
				$p\{111\}$	$r\{121\}$	$E\{261\}$.
				$q\{221\}$	$\epsilon\{362\}$	
				$\rho\{331\}$	$D\{241\}$	
				$B\{441\}$		

The forms present on each crystal were:—

No. 1. *ab*, *nmlkgu*, *xγy*, *s*, *qρB*, *ϵD*, *βE*; also deeply striated, indefinite macrodomes.

No. 2. *abc*, *nmlu*, *uxγyη*, *s*, *vχpqρB*, *δϵ*; also indefinite macrodomes.

No. 3. *abc*, *nmlku*, *hσfe*, *xγ*, *ξ*, *s*, *A*, *vχpqB*, *Cr*, *ωβ*.

The basal plane, $c(001)$, is present on crystal No. 2 as a very small face truncating the brachydomes, and it is faintly curved and striated parallel to the brachyaxis [100]; on crystal No. 3 it truncates the macrodomes, and is curved and striated parallel to [010].

Of the forms given above, $u\{130\}$ has not before been observed on Bolivian crystals, and $g\{250\}$ has been observed only by Brögger. The following are new for the mineral:—

$w\{035\}$. Two narrow, bright faces, faintly striated horizontally.

$\eta\{041\}$. Only as bright striae; observed twice.

$\xi\{312\}$. Two small bright faces striated horizontally; in the zones [112, 100], [101, 110], [302, 010], and [310, 001][1].

$A\{321\}$. Two narrow planes on the edges of the horizontal striae on $a(100)$; in the zones [101, 110], [100, 021], and [320, 001][1].

$B\{441\}$. Small planes, sometimes rather wide; deeply striated horizontally. On all three crystals.

$C\{243\}$?. Two small planes in the striated zones [120, 001]; the brightest portion of the bands fall just on either side of the zone [203, 010].

$D\{241\}$. A fairly large plane, deeply striated horizontally; in the zones [120, 001] and [211, 010].

$E\{261\}$. A small plane deeply striated horizontally and giving no bright image in the reflected band of light; in the zones [130, 001] and [211, 010].

The following are the angular measurements establishing the new forms :—

	Calculated.	Measured.
wb, 035 : 010	75° 1½′	74°22′, 75°
ηb, 041 : 010	29 17	30°, 29½°
ξe, 312 : 302	9 0½	9°7′
ξa, 312 : 100	46 3	46°
312 : (310)[1]	44 39	44°42′
Aa, 321 : 100	34 9	34°1′
321 : (320)[1]	24 46	24°, 25°
Bm, 441 : 110	17 27	17°38′, 17°18′, 18°8′, 17°24′
Dk, 241 : 120	24 17	24°
241 : (201)[1]	47 10	47°16′
261 : (201)[1]	58 16½	58°28′

On a second specimen (no. 84685), also from the San José mine at Oruro, are several small crystals of andorite encrusting the walls of cavities in massive argentiferous tetrahedrite. It is possible that some of the massive material is actually andorite since it closely resembles the crystallized material in appearance. All the fragments tested, however, contained copper, but the crystals when treated with nitric acid on a microscope-slide showed no indications of the presence of copper. The crystals are 1–2 mm. in length, and are bright, but

[1] The faces (310), (320), and (201) were not present on the crystals, but their positions were fixed approximately by means of rough graduations on the crystal adjustment arcs of the goniometer.

deeply striated in the manner described above. On one crystal, pyramid-planes were noticed in each of the eight octants. The forms determined by the goniometrical measurement of one crystal were:—*abc, nml, hfe,* $\pi\{032\}\gamma y$, *vpq*.

Mention may here be made of a magnificent specimen (no. 84659) of andorite presented to the British Museum in 1899 by Mr. Thomas J. Hooper, General Manager of the Compañia Minera de Oruro. This is from the Itos Atocha mine at Oruro; it measures roughly $30 \times 25 \times 7$ cm. and weighs $48\frac{1}{2}$ pounds. It formed part of a vein of iron-pyrites, which mineral is frequently crystallized in bright cubo-octahedra with small planes of the pentagonal dodecahedron $e\{210\}$. On this iron-pyrites, in cavities and on the surface, is deposited the andorite, numerous large crystals of which cover the whole face of the vein, or free crystallized surface of the specimen. The cubo-octahedra of iron-pyrites and the crystals of andorite on this surface are much corroded, and deposited on them, as a later growth, are one or two small cubes of iron-pyrites and a few small groups of flexible hairs of plumosite. On the back of the specimen is some pale yellowish clay.

The large crystals of andorite on the front of the specimen average one centimetre in length, but reach a length of two centimetres or more: they are of the habit shown in fig. 1 in vol. xi, p. 294 of this magazine, with deeply striated prisms and a brachydome. The faces of the brachydome are specially deeply etched, and from the pits and grooves light is reflected from minute faces parallel to the brachypinacoid and a pyramid. These crystals are too large and rough for measurement, but a small bright crystal from a cavity at the back of the specimen was found for this purpose; this crystal, on which the pyramid-planes were largely developed, showed the following forms:—*ab, nmlkgu, xyy, s, pqρ,* δr, $\omega\beta$.

On another noteworthy specimen from Oruro, the several large crystals of andorite measure $2 \times 1{\cdot}5 \times 0{\cdot}5$ cm.; they are flattened prisms (tabular parallel to the macropinacoid) with numerous well-developed terminal planes.

Note on the Systematic Position of Andorite.

In the textbooks andorite has usually been placed in the chalcostibite group, and considered to be an argentiferous zinckenite. This, however, is incorrect, as will be shown below.

The parameters given by Professor P. von Groth [1] are arrived at as follows :—

Andorite (Brögger), $a : b : c = 0.6771 : 1 : 0.4458$
Andorite (Groth), $\frac{3}{8}a : c : \frac{1}{4}b = 0.5696 : 1 : 0.5608$
Chalcostibite, $a : b : c = 0.5312 : 1 : 0.6395$

Although Groth's parameters for andorite and chalcostibite differ only in the second place of decimals, yet when the corresponding angles are compared it is seen that between one pair there is a difference of nearly 6°.

Andorite, 100 : 803 = 29° 40′, 010 : 230 = 44° 33′, 010 : 041 = 29° 17′.
Chalcostibite, 100 : 110 = 27° 59′, 001 : 101 = 50° 17′, 001 : 011 = 32° 36′.

By placing an orthorhombic crystal in one or other of the six possible positions and selecting a suitable parametral plane, it is possible to obtain an apparent agreement in the parametral ratios of any two orthorhombic minerals. Brögger's comparison of the parameters of andorite ('sundtite') and aeschynite is, indeed, closer than Groth's comparison of andorite and chalcostibite. Groth's parametral plane for andorite would be Brögger's (8.12.3), but this is not developed on the crystals, which are exceptionally rich in pyramidal planes.

Consequent upon the assumption that andorite is an isomorphous member of the chalcostibite group, Groth considers it to be an argentiferous zinckenite with the formula $(Pb, Ag_2)Sb_2S_4$, indicating that lead and silver may replace each other in indefinite proportions. There can be little doubt, however, that andorite is really a double salt with the definite formula $2(PbS.Sb_2S_3).(Ag_2S.Sb_2S_3) = PbAgSb_3S_6$. The four analyses, made independently on material from two localities, all approximate to this formula, as does also an analysis of stannite containing 8·58 per cent. of admixed andorite [2]. The following are the atomic ratios derived from these four analyses :—

	Pb	Ag [3]	Sb	S.
Loczka, 1892 . . .	0·880	0·945	2·867	6
Mann, 1894	1·004	0·900	2·896	6
Prior, 1897	0·923	1·042	3·002	6
„ „	1·013	0·975	2·990	6

In any discussion of these analytical results the following points must

[1] P. von Groth. 'Tabell. Uebers. d. Mineralien,' 1898, 4th edition, pp. 32–3. The parameters (0.5747 : 1 : 0.5618) actually given by Groth are based on the less accurate measurements of Krenner. Groth incorrectly states that andorite has a perfect cleavage ; there is no cleavage.

[2] Min. Mag., 1901, vol. xiii, p. 61.

[3] With silver is included 0.65 to 0.73 per cent. of copper. Copper minerals were not found on any of the specimens used for analysis.

be borne in mind:—(1) There is no statement of the quantity and quality of the material analysed by Loczka. (2) Mann made three analyses of material from the same specimen, one portion being andorite ('webnerite'), another consisting of needles referred to zinckenite, while the third was a mixture of these two minerals; but it is to be remarked that the third analysis is not intermediate between the two others, so there must be some error. (3) Prior's first analysis was made on only a small amount (0·2073 gram) of material not of ideal quality. (4) His second analysis, made on half a gram of pure crystals, is no doubt the most reliable of all the four analyses, and it is the one which agrees most closely with the formula proposed.

The meta-sulphantimonites of lead and silver crystallize in three distinct forms, viz.:—

1. Zinckenite, the orthorhombic lead salt, $PbSb_2S_4$, sometimes containing a fraction of a per cent. of silver. (In the isomorphous group, including chalcostibite, sartorite, and emplectite, no silver salt is known.)
2. Andorite, the double salt, $PbAgSb_3S_6$, also orthorhombic, but with no other crystallographic relation to zinckenite. (This does not fall into any isomorphous group.)
3. Miargyrite, the monoclinic silver salt, $AgSbS_2$, sometimes containing one or two per cent. of lead. (Lorandite, $TlAsS_2$, is probably isomorphous with this, but no corresponding lead salt is known.)

The relation which exists between these three minerals is exactly the same as in certain well-known cases[1] amongst artificial salts, where we have an isodimorphous (or more correctly a crypto-isodimorphous) pair of simple salts with a double salt. Thus, potassium nitrate and silver nitrate form three kinds of crystals:—

1. Orthorhombic KNO_3, with very little $AgNO_3$.
2. Monoclinic $KAg(NO_3)_2$; a double salt.
3. Orthorhombic $AgNO_3$, with very little KNO_3.

A similar case among minerals is supplied by calcite, barytocalcite ($CaBaC_2O_6$), and witherite.

A series of quite another kind in which andorite may also be placed is, as I have already pointed out[2], the morphotropic series formed by this mineral with the double (silver-lead) salts diaphorite and freiesle-

[1] See, e.g., Professor Miers's 'Mineralogy', 1902, p. 231.
[2] Amer. Journ. Sci., 1898, ser. 4, vol. vi, p. 316.

benite. These three minerals resemble each other so closely in appearance, that, as a rule, they can only be distinguished by measurement of the crystals. In all there is a prism of very nearly 90°, and taking this prism to be {110} the axial ratios, as usually accepted, become:—

		Chem. comp.	Sp.gr.
Andorite,	$\frac{3}{2}a : b : c = 1{\cdot}0157 : 1 : 0{\cdot}4458$	$RS.Sb_2S_3$	5·35
Diaphorite,	$2a : b : c = 0{\cdot}9839 : 1 : 0{\cdot}7345$	$2RS.Sb_2S_3$?	6·0
Freieslebenite,	$\frac{5}{3}a : b : c = 0{\cdot}9786 : 1 : 0{\cdot}9277$	$2\frac{1}{2}RS.Sb_2S_3$	6·3

In this series, increased basicity is accompanied by an increase in length of the vertical crystallographic axis, the vertical axes being in the ratio of approximately 3 : 5 : 6. This is the same kind of relation as that existing between the minerals humite, chondrodite, and clinohumite, and between plagionite, heteromorphite, and semseyite [1].

4. Chalcostibite from Oruro.

Two specimens of this orthorhombic sulphantimonite of copper ($CuSbS_2$) have recently been described from the Pulacayo mine, Huanchaca, Bolivia [2]. The crystals now to be described are from Oruro, which is a new locality for this rare mineral [3].

One (no. 84687) of the two specimens is that described under augelite (p. 323). The other (no. 84684), from the San José mine at Oruro, has been referred to under stannite [4]. Associated minerals are andorite, stannite, quartz, iron-pyrites, &c. The bright, tabular or blade-shaped crystals of chalcostibite occur in cavities in massive tetrahedrite, and are usually only of small size, rarely reaching 1 cm. in length and breadth. They are of a steel-grey colour, and have a brilliant metallic lustre. Parallel to the direction of the perfect cleavage, *c*(001), they are tabular in form, and in the direction of the macro-axis are

[1] Min. Mag., 1899, vol. xii, p. 66.

[2] S. L. Penfield and A. Frenzel. 'On the identity of chalcostibite (wolfsbergite) and guejarite, and on chalcostibite from Huanchaca, Bolivia.' Amer. Journ. Sci., 1897, ser. 4, vol. iv, p. 27; Zeits. Kryst. Min., 1897, vol. xxviii, p. 598; abstract Min. Mag., 1897, vol. xi, p. 338.

[3] The locality, Machacamarca, Bolivia, given in C. F. Naumann's 'Elem. d. Min.' (14th edit. by F. Zirkel, 1901, p. 451) and in C. Hintze's 'Handb. d. Min.' (1902, vol. i, p. 996), is based on F. von Sandberger's determination of 'guejarite' (Neues Jahrb. Min., 1886, vol. i, p. 89); Sandberger, however, specially states that the mineral was not chalcostibite (with which 'guejarite' has since been proved to be identical). Compare Min. Mag., 1895, vol. xi, p. 23, and p. 314, above.

[4] Min. Mag., 1901, vol. xiii, p. 64.

deeply striated. Terminal pyramidal planes are not always to be seen, and when present are usually small and irregularly developed. Though somewhat dull they give good images of the goniometer-signal, and, as is usually the case with this mineral, they have high indices.

The following forms were noted on the three crystals measured. The angles observed were in close agreement with those given by Penfield.

No. 1. $c\{001\}$, $d\{101\}$, $g\{201\}$, $q\{863\}$, $p\{6.12.7\}$. The planes p are largely developed, and the crystal closely resembles Penfield's fig. 2 (loc. cit.).

No. 2. $c\{001\}$, $\Delta_2\{103\}$, $d\{101\}$, $g\{201\}$.

No. 3. $c\{001\}$, $d\{101\}$, $g\{201\}$, $t\{021\}$, $s\{065\}$, $q\{863\}$, $\tau\{261\}$; and other small pyramids not determined, one being in the zone $[c\tau]$ and having the indices $\{6.18.1\}$ or $\{7.21.1\}$. Measured to c 86° and 86° 55′. Calculated $c:(7.21.1)=86°\,23\frac{1}{2}'$, $c:(6.18.1)=85°\,47\frac{1}{2}'$.

5. Augelite from Oruro and Tatasi.

Monoclinic crystals of this basic aluminium phosphate ($AlPO_4.Al(OH)_3$), first found in Sweden, have been recently described[1] from two localities in Bolivia, namely from Machacamarca and Tatasi, both in the department Potosi. The present description records the mineral from still another Bolivian locality.

The single specimen (no. 84687) from Oruro on which crystals of augelite have been found has the whole of the free surface, measuring about 28 × 23 cm., covered with crystals of augelite, mispickel, quartz, iron-pyrites, and stannite. There is a little kaolin, and also some minute yellow globules of cervantite (?) encrusting most of the other minerals. It was not possible to determine with certainty the order of formation of these minerals; the quartz, however, clearly belongs to two genera-

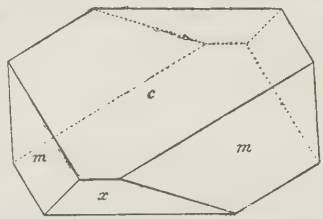


Fig. 3.—Augelite from Oruro, Bolivia.

tions, there being small crystals on the matrix, and very much smaller crystals encrusting most of the other minerals. The matrix of the specimen consists of massive quartz, iron-pyrites, and tetrahedrite. Cavities at the back of the specimen contain crystals of chalcostibite, mispickel, and stannite.

[1] Min. Mag., 1895, vol. xi, p. 16; 1898, vol. xii, p. 1.

In themselves the crystals of augelite do not differ from those previously described, but the associated minerals are not the same. The well-developed crystals are 2–4 mm. across and are present in large numbers, so that this is by far the best specimen of augelite that has yet been found. The crystals are colourless and transparent, but usually appear to be yellow and opaque, owing to the surface incrustation of cervantite (?). In habit they are tabular parallel to the basal plane $c\{001\}$; the forms $m\{110\}$ and $x\{\bar{1}01\}$ are also largely developed (fig. 3). Five crystals were measured on the goniometer, but the only other forms observed were $n\{112\}$ and $o\{\bar{1}12\}$, which are rarely present as narrow faces.

Subsequent to the publication in this magazine of the two previous descriptions of crystallized augelite from Bolivia, other specimens from Tatasi have been sent to the Museum by Mr. Roberts. On one of these specimens (Brit. Mus. no. 86723) the crystals of augelite differ from those hitherto described in having a long-prismatic development. A prismatic habit of augelite has already been mentioned, but in the crystals now referred to it is still more pronounced, and might almost be described as acicular. The prism-faces $m\{110\}$ are irregular, owing to parallel growths, and there are no distinct terminal faces. These crystals are colourless and transparent. They occur, together with pale yellow crystals (*mre*) of chalybite and small octahedra of iron-pyrites, in the cavities of a white volcanic rock (altered dacite), which is sprinkled through with iron-pyrites. Coating the other minerals in the cavities is a white, minutely crystalline mineral with a botryoidal surface; it has a specific gravity of 2·84 and was determined to be *pyrophyllite*.

6. New crystal-forms on Vivianite.

The two specimens here described were presented to the British Museum by Mr. M. Roberts; one is from Tatasi and the other from Tasna. The crystals on both have the form of a rectangular prism bounded by $b\{010\}$ and $a\{100\}$, and somewhat flattened parallel to $b\{011\}$: the predominating terminal planes belong to the form $v\{\bar{1}11\}$, and are deeply striated parallel to their intersections with $b\{010\}$. The other faces are bright and smooth, but sometimes, owing to the softness of the crystals, they have been bent by crushing. The colour of the crystals is indigo-blue by reflected light, and sea-green by transmitted light. In each case the associated minerals are chalybite and iron-pyrites, together with some other minerals on one of the specimens.

On the specimen (no. 86726) from Tatasi, two or three vivianite crystals, 1·5 cm. in length, rest on a matrix of massive chalybite, which has a botryoidal surface and is sprinkled throughout with minute crystals of iron-pyrites. The forms[1] determined on one crystal were b {010}, a {100}, y {310}, m {110}, h {250}, z {112}, w {$\bar{1}$01}, v {$\bar{1}$11} and s {$\bar{1}$31}. The new form h {250} is present on three edges as narrow, vertically-striated faces, which gave $ah = 61\frac{3}{4}°$ (calculated 61° 9′).

The specimen (no. 1905, 101) from Tasna (Eugenia vein, Gabriela gallery) consists of a matrix of brecciated tourmaline-rock cemented with chalybite, which shows large cleavage-surfaces. Associated minerals are needles of white tourmaline, bright cubo-octahedra (with small e {210}) of iron-pyrites, small crystals of chalybite in acute rhombohedra with or without prism-faces a {10$\bar{1}$}, and a few small crystals of quartz and apatite (see below, p. 338). The largest crystal of vivianite measures cm. in length and 1 cm. across.

The forms determined on one crystal are b {010}, a {100}, y {310}, {110}, w {$\bar{1}$01} and v {$\bar{1}$11}. Between m and b there are narrow planes which are striated vertically and somewhat curved: measurements to a gave in one case 66°, and in another 71°, corresponding with {130} and {140} respectively (calculated (100) : (130) = 65° 20′, 00) : (140) = 71° 0′).

On another crystal the forms are b {010}, a {100}, m {110}, n {101}, {111}, z {112}, w {$\bar{1}$01}, v {$\bar{1}$11}, s {$\bar{1}$31}, r {$\bar{1}$12}. There are also the same narrow, rounded planes between m and b, giving in this case a band of reflected images at 60°–67° from a. In the striated zone vw] there are two minute planes at 12° from w, corresponding to the position of (838) (calculated ($\bar{1}$01) : (838) = 12° 7′).

7. Tetrahedrite from Pulacayo Mine, Huanchaca.

Crystallized specimens of fahlerz from this locality are well known in mineral collections. Two distinct types of crystals may be distinguished.

In the more common type, the crystals are steel-grey in colour and have a bright metallic-lustre; the habit is tetrahedral; and the associated minerals are drusy quartz, crystals of copper-pyrites, and massive iron-pyrites. The predominating form is the triakistetrahedron n {211};

[1] The forms and angles are as given by Dana, 'System of Mineralogy,' 6th edit., p. 222. Dana erroneously gives s {311} for s {$\bar{1}$31}.

small faces of the rhombic dodecahedron, $d\{110\}$, are also present. The crystals are usually twinned, with interpenetration, about a triad axis; and these twinned crystals are remarkable in not having the full number of faces of the triakistetrahedron developed. In the octant in which the twin-axis emerges they are completely absent, being replaced by a tetrahedron face (the twin-plane) perpendicular to the twin-axis: the elevation in fig. 4 is represented as bounded at its base by the face $1\bar{1}\bar{1}$, perpendicular to the vertical twin-axis. In each of the other three alternate octants only two faces of the triakistetrahedron are developed; the third being absent or only small in size, as represented at 211 in fig. 6 (this face being here parallel to the twin-axis). Usually, also, one

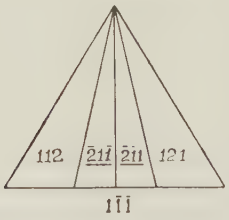


Fig. 4.

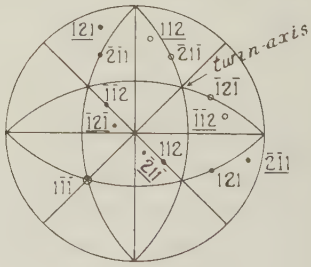


Fig. 7.

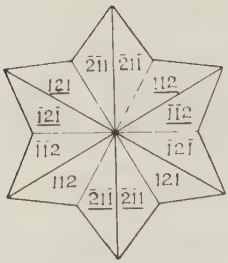


Fig. 5.

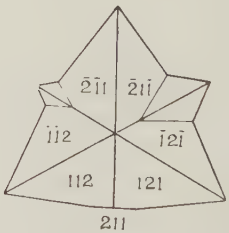


Fig. 6.

Figs. 4–7.—Tetrahedrite from Pulacayo mine, Bolivia. Plans, elevation, and stereographic projection of twinned triakistetrahedra.

of the interpenetrating crystals predominates in size, and the second crystal is present as disconnected twinned portions projecting as ridges from the main crystal (fig. 6). These projecting ridges may differ in size in the different octants, or may sometimes be altogether absent, their place being then taken by the third triakistetrahedral face of the main crystal (fig. 6).

The second type of tetrahedrite from the Pulacayo mine is much less frequently met with, and in the British Museum is represented by only one specimen (no. 86480), which came from the Hohmann collection. In appearance and habit the crystals are very like the tennantite ('binnite') from the Binnenthal in Switzerland: they also somewhat resemble crystals of black blende. The colour is iron-black; and the lustre is brilliant and metallic with a velvety appearance. The streak is black. The matrix of the specimen is a decomposed volcanic rock impregnated with iron-pyrites and kaolin. A chemical examination showed the presence of much copper, antimony, and sulphur, some silver and iron, but no arsenic: the crystals are therefore tetrahedrite, and not tennantite. The larger crystals, measuring up to 1 cm. across, are not twinned, and have only the forms $d\{110\}$ and $n\{211\}$, which are approximately equally developed. The smaller crystals are twinned, with interpenetration, about a triad axis. In addition to the forms $d\{110\}$ and $n\{211\}$, these crystals have faces in the zones [111, 110], namely, $\Delta\{774\}$, $p\{221\}$, and $\Sigma\{552\}$. These faces are somewhat uneven and oscillatory in character, and all lie with $n\{211\}$ in the same (positive) octants, the twin-plane $(\bar{1}11)$ being in an adjacent (negative) octant. Measurements in this oscillatory zone gave:

	Measured.	Calculated.
$d\Sigma = 110:552$	15° 46′	15° 48′
$n\Sigma = 112:552$	$37\frac{3}{4}°$–$38\frac{3}{4}°$	38 $56\frac{1}{2}$
$d\Delta = 110:774$	$22\frac{1}{2}°$–$24\frac{1}{2}°$	22 0
$dp = 110:221$	19° 15′	19 $28\frac{1}{2}$

The form $\Delta\{774\}$ has already been observed on fahlerz from the Pulacayo mine by G. vom Rath[1]; and $\Sigma\{552\}$ has been recorded for the Binnenthal tennantite.

8. Regular grouping of Stannite and Tetrahedrite.

A specimen (Brit. Mus. no. 86471), acquired from the collection of the late T. Hohmann, and coming from the Socavon de la Virgen at Oruro, consists of a group of bright crystals of tetrahedrite on a matrix of massive iron-pyrites. The tetrahedrite crystals are tetrahedral in habit and have the forms $n\{211\}$, $o\{111\}$, and $d\{110\}$, the first predominating, as shown in the accompanying figure: the crystals measure 5 mm. along the tetrahedral edge. On the free surface of the specimen are crystals (*oae*) of iron-pyrites, and encrusting all the other minerals are small crystals of quartz.

[1] Sitzungsber. niederrhein. Ges., Bonn, 1886, Jahrg. xliii, p. 190.

The stannite crystals are plentifully scattered over the tetrahedrite, in the surface of which they are partly embedded; they are quite small ($\frac{1}{4}$–$\frac{1}{2}$ mm. across), and of the same appearance and pseudo-cubic habit as the crystals of stannite previously described from Oruro[1]. The stannite is iron-black with a sub-adamantine lustre, while the tetrahedrite is steel-grey with metallic lustre.

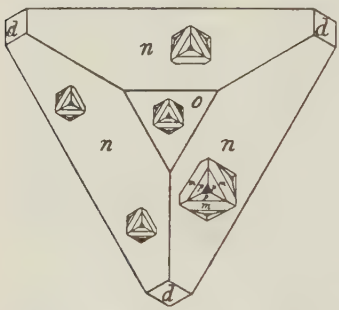


Fig. 8.—Composite pseudo-cubic crystals of stannite in parallel growth on tetrahedrite from Oruro.

The orientation of the pseudo-cubic crystals is parallel to that of the cubic crystals. The three sphenoidal planes, p (111), which in a composite crystal of stannite form a face of the pseudo-tetrahedron, reflect light with a tetrahedron face of the tetrahedrite; and the prism faces, m (110), of the former are parallel (or very nearly parallel) to the rhombic-dodecahedral faces of the latter.

9. Axial ratios and analysis of Valentinite.

Crystals of valentinite are present on four specimens from Tatasi (from the Tusti and Aranzasu veins) presented to the British Museum by Mr. M. Roberts in 1897 and 1899. The crystals are usually flattened parallel to $b\{010\}$, and are arranged in fan-shaped groups with the vertical (c) axes of the different crystals coincident. The largest group of crystals measures 1 cm. across. On one specimen, however, the crystals are not grouped together, but are scattered singly over the surface of the matrix, and they are not tabular in habit. The crystals are associated[2] with octahedra of iron-pyrites on a matrix of a compact, fibrous sulphantimonite of lead with massive iron-pyrites.

The optical characters of the crystals conform with orthorhombic symmetry. The extinction is straight on b (010), m (110), and a (100). The acute, negative bisectrix is perpendicular to a (100); and for red (Li) and yellow (Na) light the plane of the optic axes is parallel to c (001), whilst

[1] Min. Mag., 1901, vol. xiii, p. 54.

[2] On one specimen there are small crystals of chalybite, pyrargyrite, and pyrostilpnite. The *pyrostilpnite* has the form of thin blades, which, between crossed nicols, extinguish at 11° to their long edges. Goniometric measurements led to no definite results. On other specimens from Tatasi, blades of pyrostilpnite are associated with crystals of tetrahedrite.

for green (Tl) light it is parallel to $b(010)$; the axial angles are small. The refractive index was determined by Dr. G. F. Herbert Smith through prisms bounded by mm and by bm; the mean of several determinations with sodium light was 2·34. The dispersion is high, and a prism gives a long spectrum with white light.

Owing to the approximate parallel grouping of the crystals, the faces are much intergrown and are very uneven; and, owing to the softness and perfect cleavages of the crystals, they become distorted at the slightest touch. Further, the vicinal character of the faces in the brachydome zone presents difficulties in the measurement of the crystals. On many of the crystals, however, there are small, smooth, and bright faces of a pyramid, which in being developed on the free corners are less liable to distortion than the other faces.

By carefully detaching crystals, still attached to a fragment of the matrix, from a cavity of one of the specimens, the crystals were measured without being touched, and thus without danger of distortion. In this way some excellent readings were obtained from the pyramid-faces. These faces gave single, sharp images, which could often be observed with the eye-piece of the highest magnification of the Fuess no. 2 goniometer. The means of several readings on the three best crystals are :—

$$oo' = 32° 31\tfrac{3}{4}' \text{ (limits } 32° 29\tfrac{1}{2}' - 32° 34').$$
$$om = 40\ \ 9\ \ (\ ,,\ \ 40\ \ 5\ \ - 40\ \ 11\tfrac{1}{2}).$$

This pyramid is new for valentinite, and referred to the axes of Groth and Laspeyres has the indices $\{554\}$. Taking it, however, to be the unit pyramid $\{111\}$, the angles given above correspond with the axial ratios : —

$$a : b : c = 0{\cdot}3938 : 1 : 0{\cdot}4344.$$

Eleven crystals were measured on the goniometer, and the following forms determined :—

a $\{100\}$, a narrow face.
b $\{010\}$, large, giving scattered images.
c $\{001\}$, a narrow face; rarely present.
m $\{110\}$, often curved, owing to the fan-shaped grouping of the crystals and to the fibrous m cleavage.
o $\{111\}$, small, smooth, and bright faces.
χ $\{011\}$, narrow, $\{072\}$, } These are vicinal faces lying near the positions given by the indices.
ψ $\{031\}$, narrow, $\{041\}$, }

The vicinal faces in the brachydome zone are bright and smooth or striated parallel to their mutual intersections. There are usually two large and well-defined faces near the positions of *e* and *s*, which are sometimes equal in width, but often *e* is the larger. The angles (*es*) between them were measured on different crystals as: 1° 37′, 1° 45′, 3° 6′, 3° 18′, 3° 34′, 3° 40′ and 4° 5′ (two images), 3° 47′ and 4° 6′ (two images), 3° 49′ and 4° 1′ (two images), 5° 53′.

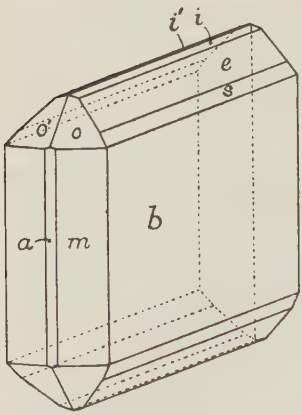


Fig. 9. — Valentinite from Tatasi, Bolivia. (The planes at the further, attached end of the crystal represent the prismatic cleavage.)

While measuring the crystals, difficulty was often experienced in separating the scattered images, and in the following table only the better angles are given. The calculated angles are deduced from the axial ratios given above.

	Calculated.	Measured.		Limits.	No.
$ii' = (011) : (0\bar{1}1)$	46° 57½′	46° 58′	46° 47′	— 47° 2′	3
$ee' = (072) : (0\bar{7}2)$	113 20	112 56	112 39	—113 20	4
$eb = (072) : (010)$	33 20	33 4	32 21	— 34 23	9
$rb = (031) : (010)$	37 30	37 3	36 19,	37 48	2
$ss' = (041) : (0\bar{1}1)$	120 9	119 42			1
$sb = (041) : (010)$	29 55½	29 43	28 44	— 30 39	9
$oi = (111) : (011)$	45 20	45 10½	45 3½	— 45 15	4
$oe = (111) : (072)$	53 59½	53 43	53 37	— 53 46	6
$os = (111) : (041)$	55 38½	55 23	55 12	— 55 34	3
$mm' = (110) : (1\bar{1}0)$	42 59	42 20	40½°	— 43½°	6

The measured angles for the vicinal faces thus vary considerably from the calculated values, but far wider variations than those recorded above were observed. The measurements of the prism-angle also varied between wide limits[1].

The axial ratios and complex indices of valentinite have been critically studied by P. von Groth (1869 and 1874), H. Laspeyres (1884), and A. Brezina (1886); but since previous calculations are based on measurements made in the brachydome- and prism-zones, the problem

[1] Values previously given for the prism (cleavage) angle are: 42° 17′ (W. Phillips, 1823), 43° 2′ (F. Mohs, 1824), 42° 18′ (P. von Groth, 1869), 41° 50′ (P. von Groth, 1874), 42° 41′ (H. Laspeyres, 1884).

has been complicated by deducing axial ratios after high indices have been assigned to the faces, which are really only vicinal in character. The parametral plane selected above, and now, for the first time, observed as an actual crystal-face, was chosen by Brezina[1] in the more likely of his two interpretations of the crystals; and, from Laspeyres's measurements, he deduced the axial ratios $a:b:c = 0{\cdot}3915:1:0{\cdot}4205$, corresponding with those given above.

These axial ratios have, however, the disadvantage of failing to indicate the isomorphism of valentinite with the monoclinic claudetite (As_2O_3). But since no analysis[2] has been made of the former mineral, there is no direct evidence that the formula is Sb_2O_3. It was, therefore, thought advisable to analyse the Bolivian crystals. For this purpose 0·5498 gram of pure crystallized material was collected by Dr. G. F. Herbert Smith and analysed by Dr. G. T. Prior, with the following results, which agree with the accepted formula Sb_2O_3:—

		Atomic ratios.	
Sb	82·79	0·693	2
O (by difference)[3]	17·21	1·084	3
As	trace[4]		
	100·00		
Specific gravity[5]	5·76		

Most of the observations recorded above were made in 1897, and although not altogether satisfactory, they may be of some value beyond recording a new locality for the mineral. The crystals were also measured by Dr. G. F. Herbert Smith, but with no further results, and he also found them to be unsuitable for accurate determinations of the optical constants.

[1] Ann. k.k. naturhist. Hofmus. Wien, 1886, vol. i, p. 145.

[2] An analysis of acicular crystals of 'white antimony' from Pereta in Tuscany gave E. Bechi (Amer. Journ. Sci., 1852, ser. 2, vol. xiv, p. 60) Sb, 78·83; O, 19·47; Fe, 1·25; gangue, 0·75 = 100·30. This suggests the formula Sb_2O_4, and is quoted by Dana ('System of Mineralogy,' 5th edit., 1868, p. 187) under cervantite.

[3] An attempt to determine the oxygen directly, by heating the mineral in a current of hydrogen and weighing the water so formed, was unsuccessful, owing to the ready fusibility of the reduced metal.

[4] Detected by the Babo-Fresenius test.

[5] The value, 5·566, usually quoted for the specific gravity of valentinite, is due to W. Haidinger (Edinburgh Journ. Sci., 1825, vol. ii, p. 73; and quoted earlier in F. Mohs's 'Grund-Riss d. Mineralogie,' 1824).

10. Cassiterite.

Specimens of cassiterite collected by Sir Martin Conway from the mountain of Huaina Potosi, near La Paz, are compact to fine-grained in texture, and light to dark brown in colour; they are often iron-stained. Except for the heaviness (specific gravity) of the specimens there would be nothing to suggest on a casual examination that the material is cassiterite. Cavities are lined with minute, very indistinct crystals of cassiterite, which are light to dark brown, and translucent to opaque. Quartz, iron-pyrites, and sometimes bismuthinite (Bi_2S_3) are present in small amounts, mixed with the massive cassiterite. In one specimen the grains of cassiterite are embedded in a dirty green chloritic substance. A thin section of this specimen shows, under the microscope, an iron-stained aggregate of cassiterite, chlorite, and quartz: the cassiterite grains are frequently twinned.

The most coarsely crystallized specimen (Brit. Mus. no. 84694 A), from the Chacaltaya mine, on Huaina Potosi, shows in the cavities dark crystals of cassiterite 1–2 mm. across. These crystals interpenetrate each other and are difficult to decipher; the faces are very uneven and curved. What appear to be hexagonal pyramids can sometimes be distinguished. Measurements show that these are really groups of six crystals twinned together in such a manner that the principal crystallographic axes and the twin-axes of all the individuals lie in the same plane. The form present is the deeply striated prism $m\{110\}$, with very narrow planes of $a\{100\}$ on a few of the edges. In fig. 10 the six individuals are marked $m_1 \ldots m_6$; of these, m_1 is placed in the normal position with the prism-edge and the striations vertical. The second and sixth crystals are twinned on $(\bar{1}01)$ and $(\bar{1}0\bar{1})$ respectively of the first crystal; the fifth and sixth are in twin position with respect to the fourth and first respectively, but not with respect to each other. This type of repeated twinning with the twin-axes all in the same plane is frequent in rutile, but rare in cassiterite [1].

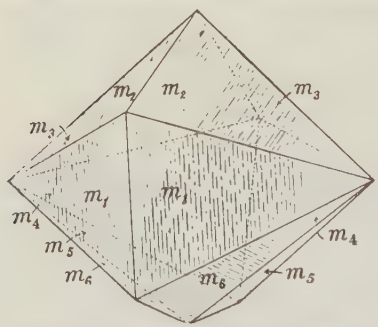


Fig. 10.—Cassiterite from Huaina Potosi, Bolivia.

Six crystals twinned together, producing a pseudo-hexagonal bipyramid.

[1] W. Phillips, Trans. Geol. Soc. London, 1814, vol. ii, p. 373, plate 25, figs. 208–15. W. Haidinger, Edinburgh Journ. Sci., 1825, vol. iii, p. 61, plate 3, fig. 7.

Sir Martin Conway's collection also includes specimens from Oruro of much the same character: they are heavy, pale brown, somewhat porous masses, with minute and indistinct crystals of cassiterite lining the cavities. In the cavities of one specimen are pentagonal dodecahedra $e\{210\}$ of iron-pyrites, and in another the cavities are lined with small quartz crystals. Massive iron-pyrites and a black mineral with metallic lustre occur in small quantities intermixed with the massive cassiterite. A thin section of a specimen from the San José mine shows, under the microscope, a porous aggregate of small, interlocking, pale yellow crystals of cassiterite. The index of refraction and the double refraction are high. Twinning is frequent, and sometimes often repeated; the line of junction between the individuals of a twin is always sharp and straight.

Compactness is a characteristic feature of Bolivian tin-ores. Crystals of cassiterite, other than those of minute size, are only exceptionally met with: in the British Museum collection there are only four isolated crystals of any appreciable size. They are simple (i. e. not twinned) crystals of prismatic habit. One of them (Brit. Mus. no. 86822) measures $20 \times 5 \times 5$ mm., and was sent by Mr. M. Roberts from Tasna; it has the forms $m\{110\}$ and $s\{111\}$. Two crystals (Brit. Mus. no. 87070) from Tres Cruces (=Quimza Cruz) in the province Inquisivi, department La Paz, were presented by Mr. John B. Minchin in 1904. The larger of these measures $21 \times 11 \times 11$ mm., and has the forms $m\{110\}$, $e\{101\}$, $s\{111\}$, $z\{321\}$, and $t\{313\}$; the prism faces are roughly striated and uneven, being replaced by oscillatory vicinal faces $\{970\}$, $\rho\{750\}$, &c. The rather smaller crystal, on which the same forms are present, is translucent and shows zonal bands of colour (brown, yellow, and almost colourless) parallel to the z planes: it is distinctly pleochroic, the absorption being greater for vibrations parallel to the vertical (c) axis, although the tone of the colours remains the same. Both Mr. Minchin and Dr. Richard Pearce have informed me that good, crystallized specimens of cassiterite, with larger crystals than those here described, are by no means uncommon at Tres Cruces.

11. Tourmaline and Tourmaline-Hornfels from Tasna.

Tourmaline of quite an unusual habit and appearance was unexpectedly found on several specimens sent by Mr. M. Roberts in 1905 from the tin and bismuth mines at Tasna, province of Nor-Chichas, department of Potosi. The mineral has the form of very fine, colourless or pale greyish-green needles, but owing to differences in the state of aggrega-

tion it varies considerably in appearance. The associated minerals are cassiterite, wolframite, mispickel, iron-pyrites, marcasite, quartz, vivianite, chalybite, apatite, and native sulphur, but these are not all present together on the same hand-specimen.

The needles, taken from different specimens, have a maximum length of 1 to 2 mm. and a thickness of 0·01 to 0·05 mm. Under the microscope, in ordinary light, they are seen to be very faintly tinged with green: sometimes the needles are slightly lighter in colour at their flat pyramidal terminations. The pleochroism is feeble, yet distinct: for vibrations parallel to the length of the needles the transmitted light is colourless, and for vibrations perpendicular thereto it is faint yellowish-green or sometimes bluish-green. The needles extinguish parallel to their length, and are optically negative. The specific gravity is 3·0. Chemical tests proved the presence of boron.

On one specimen the tourmaline forms the matrix of crystals of wolframite and mispickel[1], and has, at first sight, the appearance of a pale greenish-grey vesicular lava. This consists of a more or less compact, matted aggregate of the fine tourmaline needles, which are best seen in the round cavities, where they are more loosely aggregated. On another specimen the tourmaline needles are shorter and smaller and form a more or less compact, yellowish or dark-grey rock, somewhat resembling a sandy shale in appearance: this tourmaline-rock has been brecciated and the fragments cemented together with chalybite, on which is a later growth of tourmaline needles. On a third specimen, a few rather larger, colourless needles are confusedly grouped with quartz crystals and brilliant tin-white crystals of mispickel (forms *m* and *e*) in a cavity in massive mispickel and iron-pyrites. On a fourth, the tourmaline has the form of very fine, colourless or white, silky hairs growing out from a matrix of tourmaline-hornfels impregnated with small, indistinct crystals of cassiterite. On a fifth specimen, the bluish-greenish needles form small divergent tufts, with a velvety appearance, on the mamillated surface of brown, compact cassiterite with massive iron-pyrites. Only

[1] The *wolframite* crystals have a brilliant lustre and are tabular parallel to $t\{102\}$; the following forms were determined by the goniometrical measurement of one crystal:—$a\{100\}$, $b\{010\}$, $c\{001\}$, $t\{102\}$, $m\{110\}$, $l\{210\}$, $f\{011\}$, $\omega\{111\}$, $\sigma\{121\}$.

The *mispickel* (arsenopyrite) crystals are bright with a purplish tarnish: in habit they are exactly like fig. 2 in Dana's 'System of Mineralogy' (6th edit., 1892, p. 98), though in addition to the forms $e\{101\}$ and $m\{110\}$, which are equally developed, there are very narrow faces of $c\{001\}$.

on this last specimen is there any attempt at radial grouping of the needles; more usually they are confusedly aggregated or matted.

This colourless, acicular tourmaline is not unlike the achroite or white schorl sometimes met with in the Cornish tin mines. Such material has been described by Mr. J. H. Collins[1] from St. Austell, and in the British Museum collection there are specimens from St. Austell and St. Just.

The matrix of several of the specimens sent by Mr. Roberts from Tasna consists of a very compact, hard rock resembling in appearance a hornstone or a very fine-grained quartzite. This rock I have determined to be a *tourmaline-hornfels*. It occurs in the mineral-veins, and, on different hand-specimens, is associated with cassiterite, wolframite, native bismuth, bismuthinite (Bi_2S_3), iron-pyrites, mispickel, quartz, and tourmaline. It also appears to be of common occurrence amongst the rocks of the Cerro de Tasna, for in a collection of eighteen representative rock-specimens[2] sent by Mr. Roberts half of them are tourmaline-hornfels. One specimen, from the summit of the mountain (5,213 metres above sea-level), is a brecciated tourmaline-hornfels, with the fragments set in a matrix of silvery white scales of *pyrophyllite*[3].

These rocks are usually pale buff- or cream-coloured or greyish; sometimes they show darker bands or are spotted like a spilosite. They have a specific gravity of 2·8 and a hardness of about 7. Thin sections under the microscope show a microcrystalline aggregate of two minerals, one with the birefringence of quartz, and the other with a higher birefringence. The latter is very pale yellowish-green in colour and is not noticeably pleochroic: it predominates in the darker coloured bands and spots of the rock. The suggestion that this mineral might be tourmaline, and the rock a tourmaline-quartz-rock, was given by noticing in a small cavity of one of the specimens some small colourless needles of the same character as those described above, which were identified as tourmaline. A mixture of quartz and tourmaline in about equal proportions would have a specific gravity of 2·8. The rocks were tested for boron, and in each case gave a good flame-colour reaction.

Mr. M. Roberts, who has been actively engaged in mining in Bolivia since 1893 and at Tasna since 1903, writes (November, 1906) to me respecting the rocks of the Cerro de Tasna—'Within 400 metres from the summit there is certainly more tourmaline-hornfels than any other rock. Round the base are the shales, and in these I know of three

[1] Min. Mag., 1876, vol. i, p. 55.

[2] These include altered dacite, clay-slate, quartz-grit, and quartzite.

[3] Another Bolivian occurrence of pyrophyllite is noted above (p. 324).

dacite-dykes, which are 5 to 15 metres in width: there is no boss of dacite. . . . Personally I have never seen granite[1] in Bolivia and I feel sure that there is none anywhere in the neighbourhood of Tasna.' In a previous letter he remarked that the hard, compact 'quartzites' (i. e. tourmaline-hornfels) present a difficulty in the exploitation of the tin-veins.

There thus seems to be an abundance of tourmaline associated with the tin and bismuth ores of Tasna, and the reason why it has been previously overlooked can only be ascribed to the peculiar form which the mineral takes. The frequent occurrence of a hard, compact hornfels was mentioned by the late Professor A. W. Stelzner[2]; and he considered it to be a silicified product of the clay-slates, formed either in connexion with the mineral-veins or by metamorphic action of the dacite-dykes.

The supposed absence of tourmaline in the tin-veins of Bolivia has been especially emphasized by Stelzner[3], and hitherto only a few isolated occurrences have been recorded. In his earlier Bolivian paper[4], Stelzner mentions in a footnote the occurrence of tourmaline in the tin-veins of Chorolque; but in his later, posthumous paper[5] it is only mentioned by the editor in an appendix, the authority being Stelzner's labels with two specimens in the Freiberg collection.

D. Forbes[6] mentions it as occurring in the Baldomero mine on Mount Illampu, near Sorato, together with gold, bismuth, tetradymite, apatite, &c. Prof. T. G. Bonney[7] also notes the presence of tourmaline, in radiating groups of black acicular crystals with quartz and felspar, amongst the rock-specimens (granite, &c.) collected by Sir Martin Conway on Mount Sorata (= Illampu).

Dr. R. Pöhlmann[8] in his description of the Hohmann collection mentions eight specimens of tourmaline from Chilian and Bolivian ore-deposits. Dr. G. F. Kunz[9], in his annual report on precious stones for

[1] Specimens of granite were collected by Sir Martin Conway high up on Mt. Sorata (see 'Bolivian Andes', p. 373).

[2] A. W. Stelzner. 'Die Silber-Zinnerzlagerstätten Bolivias. Ein Beitrag zur Naturgeschichte des Zinnerzes.' Zeits. Deutsch. geol. Ges., 1897, vol. xlix, pp. 51–142 (see pp. 135–6).

[3] Loc. cit., p. 116.

[4] Zeits. Deutsch. geol. Ges., 1892, vol. xliv, p. 532 (footnote).

[5] Ibid., 1897, vol. xlix, p. 137.

[6] Phil. Mag., 1865, ser. 4, vol. xxix, p. 2.

[7] Sir M. Conway, 'The Bolivian Andes,' 1901, p. 372.

[8] Verh. Deutsch. wiss. Ver. Santiago de Chile, 1899, vol. iv, p. 83. Most of these specimens are probably from Chilian copper-lodes.

[9] Mineral Resources of the United States, for 1903, 1904, p. 966 (p. 60 of reprint).

1903, quotes, on the authority of Dr. G. F. Bandelier, 'Tourmaline.—The common black variety accompanying cassiterite occurs near La Paz.' Lastly, Dr. Richard Pearce[1] mentions the occurrence of delicate, greenish needles of tourmaline with tin-ore in the Tres Cruces district; and he has informed me that it is there rather abundant.

12. Fluorite.

In a cavity of the more coarsely crystallized specimen (Brit. Mus. no. 84694 A) of cassiterite from the Chacaltaya mine, Huaina Potosi, mentioned above, there is a group, about 1 cm. across, of corroded crystals of white fluorite, associated with quartz and limonite. The crystals appear to be octahedra, and were found to possess the physical, optical, and chemical characters of fluorite. The refractive index was determined, through a prism bounded by the cleavages, to be about 1·44.

This occurrence is of interest, since fluorite is of extremely rare occurrence in Bolivia. Both Arzruni[2] and Stelzner[3] have remarked on its absence from the tin-stone veins of this region. Curiously enough, however, worked beads of pale-yellow and rose-red fluorite have been found by A. Stübel[4] in the ancient ruins of Tiahuanaco on Lake Titicaca. It has been suggested that this material was brought by the Incas from some locality now in Peru.

D. Forbes[5] in 1861 gives fluor-spar in his list of minerals occurring in the mineral-veins of Bolivia, but he gives no precise locality or other details. I. Domeyko[6] in 1879 recorded its occurrence with the copper ores (not tin) in the Cretaceous strata at Corocoro near La Paz, and recently[7], transparent, green fluorite from this locality has been mistaken for emerald.

C. S. Pasley[8] states that fluorite is found with iron-pyrites and tin-

[1] Trans. R. Geol. Soc. Cornwall, 1906, vol. xiii, p. 105. It is here stated that Mr. D. A. MacAlister has detected tourmaline in a specimen of Bolivian tin-ore.

[2] Zeits. Kryst. Min., 1884, vol. ix, p. 75.

[3] Zeits. Deutsch. geol. Ges., 1897, vol. xlix, p. 116.

[4] Zeits. Kryst. Min., 1880, vol. iv, p. 370; 1881, vol. v, p. 580.

[5] Quart. Journ. Geol. Soc., 1861, vol. xvii, p. 60.

[6] I. Domeyko, 'Mineralojia,' 3rd edit., Santiago de Chile, 1879, p. 717.

[7] G. F. Kunz, Mineral Resources of the United States, for 1903, 1904, p. 968 (p. 2 of the reprint of Kunz's annual report on precious stones, for 1903). W. J. Humphreys (Astrophysical Journ., Chicago, 1904, vol. xx, p. 269) has noted yttrium and ytterbium to be present in this fluorite.

[8] C. S. Pasley, 'The tin mines of Bolivia.' Trans. Inst. Mining and Metallurgy, London, 1899, vol. vii, pp. 77-90. Fluorite is mentioned on p. 83.

stone at Colquiri in the province of Inquisivi, fifty miles north of Oruro. A series of Bolivian tin-ores and mineral specimens was presented by Mr. Pasley in 1898 to the Museum of Practical Geology, London, and amongst them is a specimen of green and purple fluorite from Colquiri, the determination of which as fluorite Dr. W. Pollard has been kind enough to confirm for me. Another mention of Bolivian fluorite is to be found in the Annual Report[1] for 1900–1 of the Museum Senckenbergianum at Frankfurt-am-Main: it is contained in a list of Chilian and Bolivian minerals collected by A. Gmehling, and reads 'Fluorit vom Gang Lipez (Bolivia)'.

13. Apatite.

On the specimen of vivianite from Tasna (Eugenia vein, Gabriela gallery), described above (p. 325), there are a few minute crystals of apatite. One rests directly on a crystal of vivianite, and another, with needles of white tourmaline, is attached to a small crystal of chalybite, which rests on the same crystal of vivianite. The apatite crystals are colourless and transparent, and are beautifully perfect. They are prismatic in habit, and have a length of about 1 mm. The predominating forms are the hexagonal prism, $m\{10\bar{1}0\}$, and the basal pinacoid, $c\{0001\}$. Other forms, present as small, but distinct faces, are the prism $a\{11\bar{2}0\}$ and the pyramids $x\{10\bar{1}1\}$, $y\{20\bar{2}1\}$, and $s\{11\bar{2}1\}$. The measured angles agree closely with the values given by Dana; for example, $my = 30° 30'$ (calculated, 30° 31′). A rough determination of the refractive index, by refraction through the natural prism, gave 1·64. The amount of material was too small for a determination of the specific gravity and for any chemical tests to be made. The refractive index is, however, sufficient to prove that the crystals are apatite, and not pyromorphite or mimetite.

Mention may also be made here of a fine crystal of apatite 'from Bolivia', which was presented to the British Museum in 1903 by Miss Louie Hicks, and was from the collection of her late father, Mr. George Hicks. The meteorites and mineral specimens presented to the British Museum by Mr. Hicks in 1879 were all from the Desert of Atacama, at that time in Bolivian territory, but now in Chili, and it is possible that the apatite crystal may have come from the same region; at any rate, there is nothing to connect the specimen in question with the tin deposits of the Bolivian plateau to the east of the Andes.

[1] Ber. Senckenb. Naturf. Ges., 1901, I Theil, p. 53.

This specimen (Brit. Mus. no. 86618) is an isolated, stout-prismatic crystal, broken at one end, and without any attached matrix. It measures 4½ cm. in length by 3 cm. in diameter. It is translucent and of a fine oil-green colour; but on the prism-planes there is a thin shell or skin of white, opaque material (apatite). The forms $c\{0001\}$, $x\{10\bar{1}1\}$, $a\{11\bar{2}0\}$, and $m\{10\bar{1}0\}$ are all prominently developed; the prism-faces a are wider than m, so that the pyramid-faces x are set on the corners of the former prism.

Apatite, like fluorite, tourmaline, and topaz, has been considered to be absent from the Bolivian tin-veins; and, indeed, these minerals have been only occasionally recorded from this region. This may, perhaps, be accounted for by their inconspicuousness and unusual modes of occurrence. A. W. Stelzner in his earlier Bolivian paper mentions[1] the occurrence of apatite, as a rarity, in the tin-veins of Tasna; but in his later, posthumous paper it is only given[2] by the editor in an appendix, the authority being Stelzner's label 'Apatit auf Zinnerz von Tasna' belonging to a specimen in the Freiberg collection. Other statements of the occurrence of apatite in Bolivia are the following. According to D. Forbes[3] it is found in the San Baldomero mine on Mount Illampu, near Sorata, together with gold, bismuth, tetradymite, tourmaline, &c. T. Domeyko[4] mentions large crystals of fluor-apatite from the silver mines at Aullagas, near Colquechaca.

In addition to these occurrences, certain pseudomorphous impressions in compact cassiterite have been suggested to be after apatite. Domeyko[5] mentions a specimen of tin-ore from Bolivia (Oruro or Guanuni) with impressions of hexagonal prisms terminated by obtuse rhombohedra. And Stelzner[6] mentions tin-ore from Tasna with impressions of hexagonal prisms with basal planes.

14. Cupriferous Miargyrite from Tatasi.

A specimen (Brit. Mus. no. 84307), consisting mainly of massive miargyrite with some massive iron-pyrites, was presented to the Museum

[1] Zeits. Deutsch. geol. Ges., 1892, vol. xliv, p. 532 (footnote).
[2] Ibid., 1897, vol. xlix, p. 137.
[3] Phil. Mag., 1865, ser. 4, vol. xxix, p. 2.
[4] T. Domeyko, 'Mineralojia,' 3rd edit., 1879, p. 498. The statement was first made in 1867 in the 2nd appendix to the 2nd edition (Anales de la Universidad de Chile, 1867, vol. xxix, p. 76).
[5] Bull. Soc. Min. France, 1882, vol. v, p. 299. The rhombohedral termination do not suggest apatite.
[6] Loc. cit., 1897, pp. 137, 138.

by Mr. M. Roberts in 1897. It is from the Consuelo lode at Tatasi, in the department of Potosi. In cavities there are small spindle-shaped crystals of pale yellow chalybite, some radiating groups of quartz crystals, a few small octahedra of iron-pyrites, and a powdery coating of cervantite (?). Other cavities, in which these minerals are absent, are lined with bright crystal-faces of miargyrite, but only small fragments of crystals could be detached for goniometric measurement, which gave uncertain results.

The massive miargyrite is black and opaque, and has a bright metallic lustre. Thin flakes, when examined under the microscope in bright sunlight, transmit a deep crimson colour. The streak is dark purple to reddish-brown. The fracture of the mineral is uneven to sub-conchoidal, with traces of cleavage. The specific gravity is 5·20, and the hardness $2\frac{1}{2}$. A qualitative chemical analysis showed the presence of sulphur, antimony, silver, copper, iron, and a trace of arsenic.

These characters point either to miargyrite or to a richly argentiferous tetrahedrite, and to distinguish between these it became necessary to make a quantitative analysis. I obtained the following results, which agree with the miargyrite formula, $AgSbS_2$, with part of the silver replaced by copper (Ag : Cu = 8 : 1). Lead is not present in fragments of pure miargyrite giving a purplish streak, but in an intermixed mineral of similar appearance with a black streak.

		Atomic ratios.	Calculated for $8\,AgSbS_2 + CuSbS_2$.
S	21·9	0·69	22·3
Sb	40·5	0·34	41·9
Ag	33·9	0·32	33·4
Cu	2·6[1]	0·04	2·4
Fe	1·0	0·02	
Pb	0·6		100·0
As	trace		
	100·5		

15. Miargyrite from Aullagas.

Mention has already been incidentally made in this magazine[2] of the occurrence of crystallized miargyrite at Aullagas, near Colquechaca in

[1] Two determinations gave 2·69 and 2·63 per cent. of copper. No copper mineral was detected on the specimen.

[2] Min. Mag., 1898, vol. xii, p. 12.

province Chayanta, department Potosi. The specimen, belonging to the Allan-Greg collection, there described consists of massive brongniardite and miargyrite, with some galena, pyrargyrite, and blende, and situated on the miargyrite are small octahedral crystals of argyrodite. The miargyrite is distinguished from the other minerals by its uneven fracture with traces of cleavage and by its dark cherry-red streak. It was examined chemically, and found to contain silver, antimony, and sulphur. In the cavities of the massive material some inconspicuous crystals of miargyrite were found: the following forms[1] were noted on the four fragmentary crystals measured:—

(i) b {010}, t {111}, s {211}, d {311}, ζ {$\bar{2}15$}, χ {$\bar{2}12$}, σ {$\bar{2}11$}, x {$\bar{1}22$}. A bright crystal, not much striated; b is very small. The prominent zones are $[d\,t\,x\,\sigma]$ and $[s\sigma\,\chi\,\zeta]$.

(ii) c {001}, t {111}, s {211}, h {113}, k {124}, x {$\bar{1}22$}. c is large.

(iii) Like No. 2 with d {311}, but without k.

(iv) a {100}, c {001}, t {111}, s {211}, d {311}, g {$\bar{3}13$}.

Some of the best measured angles are:

	Calculated.	Measured.
$tt' = 111 : \bar{1}1\bar{1}$	54° 55½′	54° 38′
$ts = 111 : 211$	14 17½	14 21, 14° 10′
$tc = 111 : 001$	69 18	68 50, 68° 54′
$s'\sigma = \bar{2}1\bar{1} : \bar{2}11$	32 2½	31 53
$ck = 001 : 124$	54 36	54 12

Similar crystals of miargyrite are also present on a specimen[2], labelled Potosi, which was collected by the Castelnau expedition (1843–7); the associated minerals are exactly the same as on the specimen described above, from Aullagas, department Potosi.

Mention may be made here of a large specimen of massive miargyrite, from the silver mines of the Colquechaca Company at Aullagas, a fragment of which is in the British Museum collection (no. 83989). In cavities in the bright, massive miargyrite are a few wires of native silver and some small crystals of pyrargyrite. The matrix is a brecciated, light-coloured rock, in the interstices of which are lenticular crystals of dialybite, crystals of reddish-brown blende and quartz, and some iron-pyrites and galena.

[1] The letters, indices, and calculated angles here given are those of Dana, 'System of Mineralogy,' 6th edit., 1892, p. 116.

[2] This specimen has been mentioned under argyrodite (Min. Mag., 1898, vol. xii, p. 13).

Although Bolivia has long been famous for its richness in silver, comparatively few species of silver-bearing minerals have been identified. The principal silver-ore is argentiferous tetrahedrite. The present notes add miargyrite and pyrostilpnite (p. 328) to the list [1].

16. Jarosite from Chocaya, Dept. Potosi.

A small specimen (Brit. Mus. no. 86727) from this locality, presented by Mr. M. Roberts in 1903, has the aspect of ochre-yellow semi-opal, and had been mistaken for compact cassiterite. In cavities, the surface is mamillary and encrusted with very minute, sparkling crystals of a reddish-brown colour. A little granular galena is embedded in the opal-like mass. The crystals are optically uniaxial and negative, and the massive material is finely crystalline and birefringent. The specific gravity is 3·0, and the hardness about 4. A chemical examination made by Dr. G. T. Prior proved the material to be a hydrated sulphate of iron, potassium, and sodium, and therefore to be jarosite.

17. Chalybite from Chorolque and Tatasi.

Chalybite is of rather frequent occurrence in the mineral-veins of Bolivia, but usually only as small, indistinct crystals: it is invariably associated with iron-pyrites. Fine groups of large, bold crystals are found at the Cerro de Chorolque in province Sud-Chichas, department Potosi. A specimen (Brit. Mus. no. 86468), from the Hohmann collection, shows a number of crystals, measuring $3\frac{1}{2}$ cm. along their rhombohedral edges, grouped together on the flat surface of a dark-coloured, slaty rock: the group of crystals measures 20×10 cm. Between the chalybite and the rock is some black blende with metallic lustre and a little iron-pyrites. The crystals have the form of the rhombohedron $f\{\bar{1}11\} = \{02\bar{2}1\}$, with large flat faces faintly striated parallel to their longer diagonal. The edges are rounded by etching, and the faces are also dulled and roughened from the same cause. A surface coating of clay also detracts from the appearance of the crystals. In the interior, however, they are pale yellow, transparent, and clear. There are no indications of sub-parallel grouping or curvature of the crystals, as is so often the case in chalybite; and the cleavage-surfaces, which truncate the rhombohedral edges, are perfectly bright and smooth.

On another, similar specimen from the same locality, two of the large rhombohedra, $f\{\bar{1}11\}$, are twinned with interpenetration, the twin-plane

[1] In addition to the silver minerals from Aullagas mentioned above, crystals of stephanite have been described (Min. Mag., 1898, vol. xii, p. 6, footnote).

being c (111) and the vertical axes of the two crystals coincident (fig. 11). The other crystals on the specimen are simple. This twin-law, though common in calcite and dolomite, is not mentioned in the textbooks for chalybite. On a third specimen the more deeply etched rhombohedra of chalybite form one side of a vein of bismuthinite (Bi_2S_3).

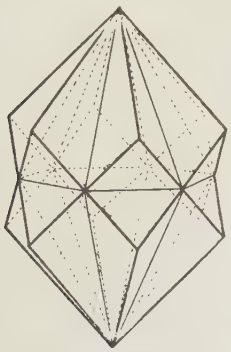


Fig. 11.—Chalybite from Chorolque.

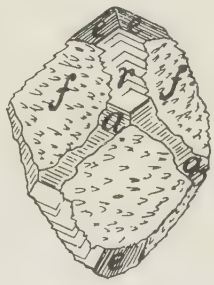


Fig. 12.—Chalybite from Tatasi, $f\{\bar{1}11\}$ twinned on (111).

Large crystals of chalybite are present on a specimen (Brit. Mus. No. 87096), also from the Hohmann collection, from the Tusti vein at Tatasi. The crystals (fig. 12), measuring 3 cm. across, are here associated with bright cubo-octahedra of galena. They have the forms r {100}, {110}, a {10$\bar{1}$}, and f {$\bar{1}$11}. The faces r, e and a are striated parallel to the zone-axis [era]; the narrow e and a being deeply striated and uneven, while the larger r is plane. f is represented only by rough, somewhat cavernous areas formed by numerous small projecting faces which reflect light together with r, e, and a. Except on the smoother faces, these large crystals have quite the appearance of being built up of small lenticular individuals with the forms r, e and a, the last being quite narrow. Several small crystals of this kind are present on the galena and on other parts of the specimen; these are pale yellow and transparent, while the larger crystals appear to be darker in colour.

Another type of chalybite crystals, more commonly met with at Tatasi, is that of small, slender spindles, 1 to 2 mm. in length. These are striated longitudinally, and under the microscope have quite the appearance of pin-points. They probably represent very acute rhombohedra with curved faces. When these crystals are dissolved in acid they leave an abundant residue of microscopic needles, which appear to be quartz.

The best examples of these spindle-shaped crystals of chalybite are to be seen in the cavities of the massive miargyrite from Tatasi (p. 340). They form a strong contrast to the lenticular crystals of chalybite associated with the massive miargyrite from Colquechaca (p. 341).

The small crystals of chalybite associated with vivianite from Tasna (p. 325) have the form of acute rhombohedra, with or without the prism $a\{10\bar{1}\}$: the faces, though plane, are too dull and drusy for their indices to be determined on the reflecting goniometer. The crystals with the augelite from Tatasi (p. 324) are short hexagonal prisms, $m\{2\bar{1}\bar{1}\}$, terminated by $r\{100\}$ and $e\{110\}$.

18. Enargite from Chorolque.

A specimen (no. 86467) in the British Museum collection is accompanied by a label in T. Hohmann's handwriting—'Enargite : Mina Coronacion, Chorolque'; and the same information appears in Hohmann's MS. catalogue. R. Pöhlmann, in his description of the Hohmann collection[1], mentions enargite from Argentina and from Chorolque in Bolivia in the form of columnar crystals 1 cm. in length.

The specimen shows a number of bright, well-developed crystals of enargite covering a surface of massive iron-pyrites and fahlerz. The only forms present are $c\{001\}$, $a\{100\}$, and $m\{110\}$, all of large size: a and m are vertically striated, and c is striated parallel to its intersection with a. The crystals are tabular parallel to a. Being closely grouped, and with the prism-edges approximately perpendicular to the underlying matrix, the crystals appear to be quite short in the direction of the vertical axis, and the bright basal planes produce a kind of tessellated surface to the specimen. The crystals measure about 1 cm. across the basal planes in their longer direction, and the bright prismatic cleavage surfaces at the edges of the specimen have about the same length.

The specimen is not unlike those from the Sierra Famatina in Argentina, but at the latter locality the crystals of enargite seem to be always associated with small crystals of quartz. I. Domeyko in his 'Mineralogia' makes no mention of enargite from Bolivia, but G. Bodenbender[2] gives Bolivia without any precise locality.

[1] Verh. Deutsch. wiss. Ver. Santiago de Chile, 1899, vol. iv, p. 80.

[2] G. Bodenbender, 'Los Minerales . . . en la República Argentina,' Córdoba, 1899, p. 54.

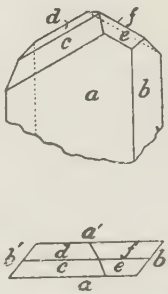
Cassiterite pseudomorphs from Bolivia[1].

By Richard Pearce, Ph.D., F.G.S.

[Read June 22, 1906.]

ONE of the peculiarities of Bolivian tin-ores is the frequent occurrence of cindery and cellular masses of cassiterite, which is presumably of secondary origin. But, apart from impressions[2] of quartz crystals, definite crystal-forms are rarely shown by this pseudomorphous cassiterite.

The pseudomorphs to be now described are from the Tres Cruces district[3], and were collected by my son, Mr. A. W. Pearce. The crystallographic determinations have been made by Mr. L. J. Spencer, and the specimens examined by him have been presented to the British Museum. The material consists of cavernous masses of dark brown, finely crystalline and granular cassiterite, associated with which is a pale yellow, ochreous substance. Some of the smaller cavities are bounded by plane surfaces, as if crystals had been dissolved out; while larger cavities are lined with pseudomorphous crystals. These are tabular in habit, and measure 2 to 4 mm. across by 1 mm. in thickness. Their surfaces have a drusy aspect, due to the crystalline development of the minute granules of cassiterite of which the material consists. Some of the pseudo-



Pseudomorph of cassiterite after an unknown mineral from Bolivia.

[1] A preliminary account has appeared under the title: 'Notes on the occurrence of pseudomorphs of oxide of tin after some unknown mineral from Bolivia,' by R. Pearce: Trans. R. Geol. Soc. Cornwall, 1906, vol. xiii, pp. 150-2.

[2] A. W. Stelzner (Zeits. Deutsch. geol. Ges., 1897, vol. xlix, p. 137) mentions cassiterite from Tasna with impressions of hexagonal prisms with basal plane, suggesting that, in this case, the original mineral was apatite. On p. 134 he mentions tin-ore from Chorolque with impressions of an octahedral (?) mineral. J. Roberts (Trans. Inst. Mining and Metallurgy, 1902-3, vol. xii, p. 404) also records the presence at Chorolque of sponge-like lumps of almost pure cassiterite with impressions of crystals. Finally, I. Domeyko (Bull. Soc. Min. France, 1882 vol. v, p. 299) makes mention of impressions of apatite (?) crystals in massive cassiterite from Bolivia.

[3] Tres Cruces (Three Crosses) or, in the Indian language, Quimza Cruz, is a mountain in the province of Inquisivi, department of La Paz, and is situated about 85 miles NNW. of Oruro.

crystals are hollow, and encrusted inside with bright crystal-faces of cassiterite.

Only indistinct and blurred images are reflected from the faces, and even with the δ-eyepiece of the Fuess goniometer only approximate measurements could be obtained. Rather better results were obtained by thinly coating the pseudomorphs with copal-varnish. The angles measured on four crystals are given under I, II, III, and IV respectively.

	I.	II.	III.	IV.
ac	31°	31⅓°	33°	30¾°
ad	80°	78¾°	78¼°	79°
ae	38°	38⅓°	—	—
af	101½°	101⅔°	102°	96°
ag	145°–149°	—	148°	150°
ah	24°–32°	—	—	—
ab	34°–40°	45°	45°	44½°

The plane angles on the face *a* were determined under the microscope to be approximately 120° on each of the four crystals; i. e. the angles between the zones [*acd*] : [*aef*] and between [*aef*] : [*ab*] = 60°.

Crystal I is represented in the accompanying figure; *g* is a narrow face on the edge *fa'*, and *h* is a rounded surface between *a* and *b*. Crystals II, III, and IV differ from no. I like the opposite ends of a monoclinic crystal, the faces *b*, *e*, and *f* being on the left-hand side of *a*. From the above table of angles it will be noticed that the angles in the zone [*acd*] are supplementary to those in the zone [*afg*], the measurements from *a* in one zone being approximately the same as those from the parallel face *a'* in the other zone: this proves the presence of a dyad axis of symmetry. The crystals are therefore monoclinic, with the plane of symmetry perpendicular to the faces *a* and *b*. They are tabular parallel to what may be taken as the basal pinacoid (*a*), and are attached at one or other end of the dyad axis.

In having plane angles of 120° on the basal plane, the crystals simulate rhombohedral symmetry, like the micas, polybasite and pearceite, xanthoconite, &c. The interfacial angles of the pseudo-crystals do not, however, correspond with the angles of any of these minerals. In general habit the pseudomorphs are not unlike axinite, but here again there is no correspondence between the angles. It must therefore remain doubtful what was the original mineral of these pseudomorphs.

Another suggestion as to what might have been the original mineral

is given by the following partial analysis of the yellow ochreous material associated with the pseudomorphs:—

Fe_2O_3	28·24 per cent.
PbO	17·67
SO_3	16·70
As_2O_5	4·05
Insoluble (mainly cassiterite)	7·0

At 200° C. no loss.

The presence of lead suggests that the pseudomorphs may have originated by the alteration of a sulphostannate of lead. The occurrence of sulphostannates, viz. stannite, canfieldite, teallite, franckeite, cylindrite, and plumbostannite, is a peculiar feature of the silver-tin lodes of Bolivia; and, with the exception of stannite, none of them are known to occur outside this region. Although there is no agreement between the crystalline forms of these minerals and the pseudomorphs described above, it does not seem at all unlikely that some, at any rate, of the pseudomorphous cassiterite of Bolivia may have been formed by the alteration of sulphostannates.

On the occurrence of Linarite and Caledonite in County Wicklow.

By Arthur Russell.

[Read March 20, 1906.]

TO the north-west of Rathdrum, in the county of Wicklow, three important groups of lead mines were formerly worked, which are known respectively as the Glendasan or Luganure, Glendalough, and Glenmalure mines, after the mountain glens in which they are situated. The lodes traverse the granite in a north and south direction close to its junction with the mica-schist, and are somewhat remarkable for the variety of their mineral contents.

During the summer of 1904, while examining the old burrows of the Moll Doyle mine in the vale of Glendasan, I came across two or three small specimens of a quartzose vein-stuff showing spots of chalcopyrite, malachite, and a deep azure-blue mineral. The quantity of the blue mineral was too small for a chemical examination, and I was unable to determine the species, but the general appearance and association at once recalled the linarite of Red Gill in Cumberland.

In February, 1906, I revisited the district, and while searching on the burrows of the Ballinafunshoge mine in the vale of Glenmalure, some four miles to the south of the Glendasan mines, I was fortunate enough to find several larger and more clearly defined specimens of the blue mineral. A qualitative chemical test made on one of these proved the mineral to be linarite. Two of the specimens show sharp, though minute, characteristic prismatic crystals, about 1 mm. in length, flattened parallel to s $(\bar{1}01)$ and elongated parallel to the edge of the zone $[ac]$. The forms present are $a\{100\}$, $c\{001\}$, $s\{\bar{1}01\}$, $m\{110\}$. For the identification of the forms I am indebted to Dr. G. F. Herbert Smith, who, at my request, kindly measured one of the crystals. In the case of the Ballinafunshoge specimens the associated minerals are a peculiar black cerussite, malachite, and yellowish quartz. On two of the specimens the linarite occurs as small, indistinct crystals forming a crust on a decomposed granitic rock.

Associated with the linarite from the Moll Doyle mine there is, in

addition to chalcopyrite and malachite, a very small quantity of a pale greenish, pearly mineral, which is most probably aurichalcite.

The caledonite, of which only one specimen was found, occurs associated with the linarite as minute, though characteristic, bluish-green crystals implanted on the black cerussite from the Ballinafunshoge mine. The mineral was determined by a qualitative chemical test. The crystals were too intergrown and the faces too uneven to allow of crystallographic measurement.

Since the publication in 1868 of Townshend M. Hall's 'Mineralogist's Directory', comparatively few additions have been made to our knowledge of Irish mineral localities. I am therefore pleased to be able to add the names of two minerals which I believe to be new to that country. The two species are not included in the preliminary and supplementary lists of Irish minerals given by Mr. Henry J. Seymour in the British Association Reports for 1902 and 1903.

Note on the mines and minerals of the Silvermines district, Co. Tipperary.

By Arthur Russell.

[Read March 19, 1907.]

THE Silvermines mineral district is situated along the northern base of the Silvermine Mountains, five and a half miles south of the town of Nenagh in the county of Tipperary. The district is one which possesses somewhat remarkable features, of interest to both geologists and mineralogists. The mines extend over a narrow tract of country for a distance of about five miles along an extensive E. and W. line of fault, in which Silurian, Old Red Sandstone, and Carboniferous rocks are brought into juxtaposition. This line of fault has been traced for a distance of about thirty miles from Gallows Hill in co. Clare, on the west, to Toomavara in co. Tipperary, on the east. Along its course in at least two places mineralization has taken place, resulting in a somewhat complex series of contact-lodes and metasomatic deposits.

Mining operations in search of silver-lead were evidently carried on at Silvermines at a very early date, the whole district being literally honey-combed with ancient open workings, shafts, and levels. Actual records date back to the year 1600, and mining was carried on intermittently down to 1800. The mines were then taken over by the General Mining Company of Ireland, which carried on extensive operations down to 1870. Since that date, little or nothing has been done beyond the clearing up, a few years ago, of a shaft and the raising of a small quantity of calamine-ore at Ballygown South mine.

The general geology and many features of the mines of this district have been very ably described in the Explanations accompanying Sheet 134 of the Irish Geological Survey, which was published in 1861. I purpose, therefore, to deal mainly with the mineral contents of the lodes, as exemplified by specimens lately found by myself on the old mine burrows. As is usual in Ireland, the mines are mostly named after the township in which they are situated. Commencing with the most easterly of the group and going westward, we will consider any points of mineralogical interest.

Just south and close to the little village of Silvermines lies the *Ballygown South mine*. Here, along the line of fault, the Carboniferous

Limestone is brought down against the Old Red Sandstone; the former rock being converted into a hard, grey, crystalline dolomite, extending in places as a narrow strip along the north side of the fault, and passing insensibly into the surrounding Carboniferous Limestone. Running at right angles to this strip of dolomite, and dipping about 10° N. below the limestone on which the village stands, is a very remarkable bed of rusty ochreous gossan about 20 feet thick. Both the foot-wall and hanging-wall are entirely composed of dolomite, whilst the gossan itself frequently contains great irregular rounded masses of dolomite; these in all probability having resisted the general metasomatic action. The bulk of the gossan is composed of cellular and sponge-like masses of brownish-yellow limonite, the cavities and surfaces of which are often lined with drusy crusts and brilliant crystals of hemimorphite (calamine). In other cases the hemimorphite forms with galena solid, irregular lumps, often of considerable size, the exterior and cavities being studded with crystals. The calamine-ore was first discovered by Captain Thomas King, the resident manager of the mines, who in 1858 sent a sample taken from the bottom of an ancient shaft to Dublin, where it was examined by Dr. Apjohn. The latter analysed the mineral, and showed it to be basic silicate of zinc, or hemimorphite[1].

The hemimorphite crystals, though of comparatively small size (the largest noted being 2 mm. long), are wonderfully brilliant and sharp. They resemble the well-known Aix-la-Chapelle specimens, and are fairly rich in faces about the analogous pole. The crystals are tabular parallel to the brachypinacoid, b {010}, the b face being vertically striated. They are usually attached to the matrix by the antilogous pole; in a few cases, however, both poles are developed. The following forms were noted: {010}, c {001}, m {110}, t {301}.

The deposit of calamine-ore at Silvermines is of especial interest as being the only occurrence of the kind known in the United Kingdom. In many of its features it presents great similarity to the well-known deposits at Moresnet in Belgium. From the fact that small quantities of blende and galena have from time to time been found amongst the zinc-bearing gossan, it seems probable that the metallic contents were originally deposited in the form of sulphides along the line of fault and

[1] J. Apjohn, 'On the occurrence of electric calamine at the Silver Mines, County of Tipperary.' Journ. Geol. Soc. Dublin, 1860, vol. viii, pp. 157–9. See also A. B. Wynne, 'Some remarks upon the mining district of Silvermines, County of Tipperary, with a map.' ibid., pp. 244–50; J. Beete Jukes, 'Note on the way in which the calamine occurs at Silvermines, County of Tipperary.' ibid., 1863, vol. x, pp. 11–13.

side-fissures. Subsequently, underground waters by their metasomatic action brought about the gradual substitution of the surrounding limestone by silicate of zinc and oxide of iron. The existence of large quantities of barytes would point to an intermediate stage in which the sulphur of the sulphides underwent oxidation.

In addition to the hemimorphite, the gossan often contains irregular masses of galena, partially altered to cerussite, and occasionally small quantities of blende. The galena was said to contain 80 ounces of silver to the ton. Barytes is also of frequent occurrence either in curious radiating and stalactitic masses, the exterior coated with pale yellow, earthy limonite, or in aggregations of simple wedge-shaped crystals ($c\{001\}, m\{110\}$) grouped in parallel position. Smithsonite (zinc carbonate) is said to have occurred in the gossan, but I failed to detect this mineral.

Adjoining the Ballygown South mine, and a little to the south, is a large contact-lode, composed mainly of pyrite, known as the *Sulphur mine*. Old Red Sandstone forms the southern wall, whilst the northern is composed of dolomite. Large quantities of pyrite were formerly raised here, but nothing of mineralogical interest presents itself.

At the *Gortshaneroe* or *Ballynoe mine*, chalcopyrite, galena, and barytes form a lode between walls of Silurian and Carboniferous Limestone rocks. Close to this spot in the bed of a stream is a remarkable deposit of barytes said to contain spots of pyrite and orpiment. This occurrence of orpiment was recorded in 1860 by Mr. Alphonse Gages[1].

At the *Gorteenadiha* or *Gortnadyne mine*, very extensive mining operations were formerly carried on, principally for copper, although a considerable quantity of lead was also raised. The principal lode lies between Old Red Sandstone and Carboniferous Limestone. The vein-stuff consists of a hard quartz-sandstone-breccia, containing irregular patches of chalcopyrite, whilst in places argentiferous tetrahedrite is abundant, and may be found on the old burrows associated with large masses of white barytes. The barytes is particularly abundant at this mine, and is often very pure. Good specimens of white acicular cerussite (called by the miners 'cat-tooth-ore'), often stained with malachite or azurite, are common.

The once important mines of *Shallee East* and *Shallee West* form the limit on the west on which mining operations have been carried out.

[1] A. Gages, 'On the formation of orpiment in a mass of sulphate of barytes, found interstratified in the Carboniferous Limestone near Silvermines, County of Tipperary.' Journ. Geol. Soc. Dublin, 1860, vol. viii, pp. 243–4.

The Shallee East mine presents a very remarkable appearance, the whole base of the mountain-side being furrowed with a very extensive series of open workings made in search of lead-ore. These open workings vary in width from 3 to 6 feet, and occasionally extend for a distance of 20 yards; they average about 30 feet in depth. Their direction is more or less at right angles to the main line of fault, and they evidently represent a series of side fissures in which mineralization has taken place from a common source. The enclosing rock is a dirty grey, quartzose sandstone. The galena occurred more or less intimately associated with white, massive barytes, the latter mineral forming a large portion of the vein-stuff. Argentiferous tetrahedrite and cerussite are also present in small quantities.

The compact nature of the vein-stuff and the absence of vugs have precluded the formation of crystallized minerals, which, with the exception of hemimorphite and barytes at Ballygown South mine, appear to have been of extremely rare occurrence in this district.

List of Minerals occurring in the Silvermines district, co. Tipperary.

Ballygown South mine (Calamine mine):—
Hemimorphite (Calamine), Smithsonite? Blende, Galena, Cerussite, Pyrite, Limonite, Barytes.

" " " (Sulphur mine):—
Pyrite, Galena, Blende.

Gortshaneroe or Ballynoe mine:—
Galena, Chalcopyrite, Pyrite, Orpiment, Barytes.

Garryard West mine:—
Galena, Cerussite, Pyrite.

Gorteenadiha or Gortnadyne mine:—
Chalcopyrite, Tetrahedrite, Malachite, Azurite, Galena, Cerussite, Blende, Hemimorphite, Pyrite, Barytes.

Shallee East or Shallee Coughlan mine:—
Galena, Cerussite, Tetrahedrite, Barytes.

Shallee West or Shallee White mine:—
Galena, Barytes.

The following additional minerals from this district are mentioned by Townshend M. Hall in his 'Mineralogist's Directory', 1868:—Erythrite at Silvermines; Pyromorphite at Shallee Mountain.

A new model of Refractometer.

By G. F. Herbert Smith, M.A., D.Sc., F.G.S.

Assistant in the Mineral Department of the British Museum.

[Read January 29, 1907.]

THE instrument described in this paper is identical in principle with the small refractometer[1] designed by the author more than three years ago, but differs from it in several details which are of considerable practical importance. As in the earlier form, a compensative lens is introduced of such curvature and focal length that the focal surface of the optical combination is a plane within the range for which the instrument is required, and consequently the critical edges are sharply defined in monochromatic light for all positions. It will be more convenient, before entering into the description, to take the features which have been changed.

1. As will be seen from the illustration (fig. 1), the aspect of the refractometer has been completely altered. The awkward corner existing close to the dense glass in the earlier form has been obviated, and now the whole of the parts lie on the same side of the plane of the brass plate carrying the dense glass which forms the constant medium ; there is, therefore, practically no limit to the size or to the shape of a stone for which the instrument may be used, and it matters not if it be surrounded by a wide setting. In the case of the earlier instrument the table-facet of a large stone, or of one mounted, for instance, in a brooch, often could not be brought on to the plane surface of the dense glass. Of course, a small facet would answer the purpose equally well; but the author is aware, from experience, of the difficulty of assuring that a small facet of a large stone is pressed evenly against, and not inclined to the surface of the glass. Any such uncertainty might render the observations valueless, and, moreover, there is great risk of scratching the surface of the dense glass. The same kind of difficulty not infrequently arises in the case of jewellery.

2. The instrument is larger in size; indeed, the focal length is precisely double what it is in the smaller form, and delicacy of the readings has been correspondingly increased.

[1] Min. Mag., 1905, vol. xiv, pp. 83–6.

3. The scale (fig. 2) is no longer arbitrary, but gives the refractive indices for sodium-light directly to the second place of decimals, and the intervals are such, particularly in the higher values, that the tenth parts may be estimated with some certainty, and a trustworthy value, therefore, obtained of the indices to the third place of decimals. Previously the scale was quite arbitrary and had to be calibrated by means of observations of substances of known refractive indices, and after an observation had been taken reference had to be made to a card on which was given the equivalents in refractive indices of the divisions on the scale. If the card were lost, the instrument was useless until it had been recalibrated. At the same time the range has been increased by at least a whole unit in the second place of decimals, and extends now to 1·770. The limit varies slightly with the instrument, depending as it does on the amount to which the plane surface of the dense glass projects beyond the brass plate embracing it, and may be as high as 1·775. In the earlier form the higher limit is rarely much above 1·750 and never exceeds 1·760. The extension is of extreme importance, since the range now includes the refractive indices of corundum, a species which occupies such a prominent place among gem-stones that the direct determination of the refractive power greatly increases the utility of the instrument. In the earlier refractometer it was, indeed, possible to see in white light the violet end of the coloured edge

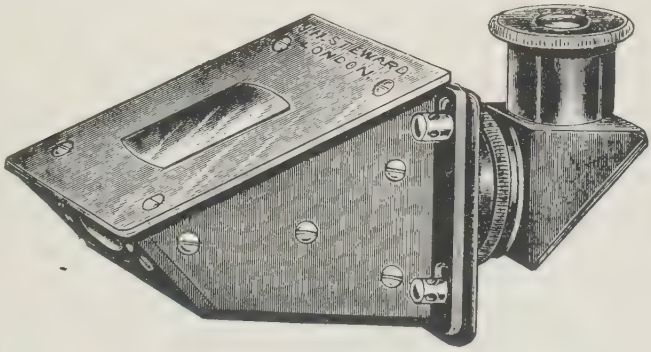


Fig. 1.—Refractometer (actual size).

corresponding to the extraordinary index in the case of all save the deep-red stones; but bright daylight was required for a trustworthy observation, and such a determination cannot be considered so satisfactory as an actual measurement of the refractive indices.

4. A lens, of one inch (25 mm.) focal length, has been substituted for

the ground-glass plate through which light is admitted to the instrument. Owing to the extreme shortness of the focal length of the telescope—as optically considered the instrument really is—the image of the surface of the ground-glass plate is formed so near the focal plane as to be within the accommodating power of the observer's eye, and consequently not only is an exact appreciation of the position of the critical edge rendered difficult, owing to the apparent diffusion of the edge, but a course of observations becomes most fatiguing by reason of the incessant change in the eye's focal adjustment. The lens throws outside objects, such as window-bars, the sodium-flame, &c., sufficiently out of focus that no inconvenience is experienced. If white light be employed, the most satisfactory illumination is obtained by using the diffused light reflected from a sheet of white paper laid on a table.

Fig. 2.—Scale of Refractometer.

It will simplify the description of the refractometer as regards the orientation of the various parts, if we suppose that the divisions of the scale are horizontal, whence it results that the optic axis of the combination formed by the dense glass and the compensative lens is also horizontal, and, further, if we suppose that we are viewing the instrument from the end, having the eye-piece towards us.

The constant medium, with which in a total-reflectometer the substance under examination is compared, is a highly refracting glass having an index for sodium-light of 1·7902. A denser glass, of refractive index 1·8924, is used in the type of total-reflectometer of greater precision which possesses rotational parts; but it is unfortunately so soft, fragile, and wanting in durability as to be little adapted to the purposes of a determinative instrument in constant use. Even in the case of the less dense, but more durable glass, great care must be taken not to scratch the surface when observations are made on the far harder gem-stones.

The glass is cut to the shape of a hemisphere, 1 cm. in radius, which is sliced vertically and symmetrically with regard to its centre to a convenient width, slightly exceeding that of the part of the field utilized. If desired, the shape may be a portion of a semi-cylinder, the circular section of which has the same radius, viz. 1 cm. The brass plate surrounding the dense glass is cut away and bevelled so that the plane surface of the latter projects slightly above the plate. The glass is firmly held in position from the two sides, but can be

readily removed for repolishing without any risk of injury. In the case of the earlier instrument the dense glass is fitted in from above and burnished into position; i. e. a thin strip of metal is turned over the bevelled edge of the glass. Owing to its brittle nature, it is an operation of extreme delicacy thus to fix the glass in the right position, and, when once fixed, it cannot be removed without almost certain damage.

The brass plate, just mentioned, forms the top of the box, quadrilateral in shape when viewed from the side, which contains in addition to the dense glass the compensative lens. Of the sides of the quadrilateral figure, the base is horizontal; the right-hand side is vertical; and it and the left-hand side make equal angles, viz. 61°, with the upper side, i. e. the brass plate surrounding the dense glass. The left-hand side contains the lens through which light is admitted to the instrument. The right-hand side is the plate which is attached by means of four screws passing through holes in it, slotted vertically, to the corresponding plate which carries the scale and the eye-piece, and the former plate is cut away in the centre to admit the tube carrying at its inner end the scale. The upper plate is attached to the sides of the box, as may be seen from the figure, by means of four countersunk screws, which pass through holes in it slotted lengthwise—a means for varying slightly the distance between the dense glass and the compensative lens. The plate is hollowed out underneath from front to back, i. e. lengthwise, about the width of the dense glass in order to extend the range of the instrument as high as possible.

The compensative lens is carried in a frame, which may be moved up and down in two vertical grooves, fixed to the side plates, the motion being given by a screw, the head of which emerging through the bottom plate is actuated by a key and is covered by a cap to prevent accidental interference with the adjustment. The frame itself is cut away at the top so that the lens may fit into the groove hollowed out of the upper plate, the curvature of which is such as to accommodate the lens.

The tube, which carries at its inner end the scale, may be pushed in or out of the fixed tube surrounding it in order to bring the scale into focus and rotated to bring it upright, i. e. the divisions horizontal, and is held rigidly, when in the correct position, by means of a clamp of the ordinary split-ring type. The top of the tube at the inner end is filed away so that the top of the scale, or the bottom as seen in the eye-piece, may fit into the groove in the upper plate.

The scale, as has been stated above, gives the refractive indices for sodium-light direct to the second place of decimals, and the graduation

extends from 1·300 to 1·775. The intervals between the divisions increase in size with the index, and to facilitate the estimation of the tenth parts the intervals from 1·650 upwards have been bisected. All the lines are drawn from the centre of the field towards the left, and every fifth is distinguished by its greater length. The readings are intended to be taken just at the point where the critical edge meets the right-hand edge of the scale, i. e. in the centre of the field; for, when the curved surfaces of the dense glass and the compensative lens are spherical, the critical edges are slightly curved, being circular arcs, and it is, of course, essential to know what part of the curve is to be observed. The difficulty does not arise in the case of cylindrical surfaces, because the edges are straight.

The eye-piece is of the ordinary positive type and magnifies about ten times; for convenience of observation a totally-reflecting prism is inserted between the two lenses. Since the eye-piece cannot be pulled out far without consequent unsteadiness, an adaptor can, if desired, be provided for observers with long sight.

In order to maintain during observation the stone in position upon the plane surface of the dense glass, and especially to minimize the risk of the stone falling off the instrument, light springs of German silver are provided. They are shaped like the Greek letter Ω, so as to grip the sides of the instrument, and vary in length to suit different sizes of stones.

All the instruments are made as closely as possible to the same pattern; but, of course, certain adjustments are necessary, which are as follows:—

1. The scale is fixed into its frame in as nearly as possible the same position in each instrument. To bring it into the correct position in the focal plane, the compensative lens is first screwed up until almost in contact with the upper plate; the screws holding the two parts of the instrument together are then slightly released, and the two parts moved relatively to each other in a vertical direction until the reading of the scale for the critical edge given by some known, preferably in all these preliminary tests singly refractive, substance is within a division of the truth; the final adjustment is effected by means of the screw adjustment to the compensative lens.

2. The focal length of the optical combination must be the same in all cases, because otherwise a troublesome correction to the readings of the scale would be necessary. The curvatures of the surfaces of the dense glass and of the compensative lens are invariable, and the only adjust-

ment required, viz. the distance between the two constituents of the optical combination, is provided for by the slotting of the holes in the upper plate.

Unless there has been some error in the workmanship, the correct adjustment of the refractometer presents little difficulty. The scale is first brought into the focal plane and rotated until the divisions are horizontal, and is then securely clamped; as a criterion the critical edge given by some known substance is employed. The scale is next adjusted vertically in the manner described above until the reading for the edge is correct. Readings are now taken for two substances which give edges near the opposite ends of the scale. If the readings cannot be made simultaneously correct, the interval between the dense glass and the compensative lens is varied to the extent required. A last glance to see that all the screws are properly tightened, and the refractometer is ready for use.

This refractometer, like the earlier form, is the work of the well-known optician, Mr. J. H. Steward, 457 West Strand, London, W.C. To Mr. John Steward of that firm the author acknowledges an especial debt of thanks for many valuable suggestions for overcoming the various difficulties which almost inevitably arise in the construction of a new form of instrument.

A simple arrangement and notation of the thirty-two classes of symmetry based on the symmetry of zone-axes.

By John W. Evans, LL.B., D.Sc., F.G.S.
Adviser in Mineralogy to the Imperial Institute and Lecturer on Mineralogy at Birkbeck College.

[Read January 29, 1907.]

IF a straight line making an angle with a zone-axis of a crystal be rotated about the zone-axis while the crystal remain fixed, the physical characters of that line will pass through a cycle of changes. If these changes repeat themselves n times during the course of a complete revolution, the zone-axis is said to have an nth-turn or n-fold cyclic symmetry. If the line be at any time normal to a crystal-face it will be normal to a face with the same physical characters n times during such a revolution.

If the order of succession of the changes be dependent on the sign of the direction of rotation, the zone-axis is said to be 'unilateral' or 'haplo-cyclic': if the order be the same for opposite directions of rotation, it is 'bilateral' or 'amphi-cyclic'[1].

The symmetry *round* a zone-axis, or its cyclic symmetry, may therefore be expressed by the cyclic number of the zone-axis, which may be I, II, IV, III, or VI, and its character whether unilateral (U) or bilateral (B).

A zone-axis has two opposite longitudinal directions. The termination corresponding to one of these may be defined as the aggregate of all straight lines making an angle of less than a right angle with such direction—as well as the faces to which any of such lines are normal. The two terminations of a zone-axis may be expressed by means of the zone symbols thus: T [uvw] and T [$\bar{u}\bar{v}\bar{w}$].

The symmetry *along* a zone-axis, or its 'longitudinal' symmetry, expresses the relation between its two terminations.

If there be no symmetry connecting the two terminations, other than symmetry round the zone-axis, the terminations will be unlike and the

[1] The number of the planes of symmetry passing through a bilateral zone-axis is that of its cyclic symmetry. If this number be odd, they are all like; if it be even, they fall into two equal groups of unlike planes. A unilateral zone-axis has no planes of symmetry passing through it.

zone-axis is said to be uniterminal (u). In this case, if the zone-axis be unilateral, the crystal and its reflexion are not superposable.

If the two terminations of a zone-axis are similar it is said to be biterminal. In such cases the terminations may be related in different ways.

If one termination be the reflexion of the other in a plane of symmetry at right angles to the zone-axis, the longitudinal symmetry is said to be reflected (r).

If one termination can be derived from the other by reflexion and a half turn round the zone-axis, the axis is said to have 'longitudinal half turn' or 'central' symmetry (c). The crystal has symmetry about a point, and opposite directions on any straight line have the same physical characters. If the number of the cyclic symmetry be even, reflected and central symmetry are identical.

If one termination be derived from the other by reflexion and a quarter turn, the axis has 'longitudinal quarter turn' symmetry (q). It can be easily shown that this only gives rise to new forms of symmetry if the number of cyclic symmetry be II; in other words, if there be a half turn symmetry round the zone-axis. It can be also shown that longitudinal one-third turn and one-sixth turn symmetries give no new forms.

In all cases where the longitudinal symmetry of a unilateral zone-axis involves reflexion with or without rotation the two terminations are not superposable, but the crystal and its reflexion are superposable.

One termination may also be derived from the other by rotation through a half circle on a zone-axis at right angles to the original zone-axis. If the symmetry round the axis be bilateral, the relation between the terminations will be the same as in the case of central symmetry. New forms of symmetry are therefore only obtained when the cyclic symmetry is unilateral. In such cases the longitudinal symmetry may be referred to as 'helical' (h), because the two terminations are related in the same manner as the ends of a screw[1]. The terminations are superposable, but a crystal and its reflexion are not superposable.

[1] The number of secondary axes will be equal to that of the cyclic symmetry of the original axis. If that be odd, they will be all alike and uniterminal. If it be even, there will be two equal groups of unlike helical axes.

If a straight line at right angles to a helical zone-axis be rotated about it, the order of succession of changes of physical characters will be the same for opposite directions of rotation, except that the relation of such characters to opposite ends of the zone-axis will be reversed. In like manner and subject to a similar proviso, the faces of a helical zone exhibit the same succession in opposite directions. These relations do not exist in the case of other unilateral zone-axes.

The full symmetry of a zone-axis may therefore be expressed by the conjunction of the different kinds of symmetry which it exhibits, and be indicated by the association of their symbols; thus the symmetry of the principal axis of idocrase may be described as 'fourfold' or 'quarter turn' 'bilateral central', or it may be more briefly and conveniently referred to by the symbol IVBc. If desired for the sake of brevity, the words 'whole turn' and 'unilateral' may be omitted, thus the symmetry of the principal axis of scapolite or scheelite may be described as 'quarter turn unilateral central' or simply 'quarter turn central', but the full symbol IVUc should always be used. The symmetry of a zone-axis of crystals of the asymmetric, calcium thiosulphate, class would be 'whole turn unilateral uniterminal' or simply 'uniterminal,' with the symbol IUu.

The thirty-two classes of crystal-symmetry may be distinguished by the symmetry of the zone-axis having the highest number of cyclic symmetry and may be referred to by the corresponding symbols. Those classes which have four axes of threefold or one-third turn cyclic symmetry are said to be 'cubic' with the symbol 4III or C.

The classes are first grouped by the number of the characteristic cyclic symmetry, the cubic classes forming a separate group. These groups are subdivided, first, according as the cyclic symmetry is bilateral and unilateral, and secondly, by the character of the longitudinal symmetry.

In the first table which accompanies this paper each class is represented by its symbol accompanied by the name of a substance crystallizing in it, when such is known to exist. The classes with the same number of cyclic symmetry are arranged vertically, and those that agree in their unilateral or bilateral character and longitudinal symmetry horizontally[1]. It will be seen that all the vertical columns except that of the whole turn symmetry have *unilateral* uniterminal, helical, and central symmetry and *bilateral* uniterminal and central symmetry. These give $5 \times 5 = 25$ classes; the whole turn column has three classes, and the half turn column and one-third turn column have each two extra classes, making the full total of thirty-two classes.

In the second table, each symbol is followed by the crystallographic system and the number of the class according to Professor Lewis ('Crystallography,' 1899) and Professor Miers ('Mineralogy,' 1902 p. 280).

This classification presents many points of resemblance to those o

[1] It is convenient to arrange the different kinds of longitudinal symmetry in an order different from that in which they have been described.

TABLE I.

	Whole turn.	Half turn.	Quarter turn.	One-third turn.	One-sixth turn.	Four one-third turns or Cubic.
	I.	II.	IV.	III.	VI.	4III or C.
UNILATERAL (U).						
Uniterminal (u).	IUu Calcium thiosulphate.	IIUu Cane sugar.	IVUu Wulfenite.	IIIUu Sodium periodate.	VIUu Nepheline.	CUu Ullmannite.
Biterminal						
Helical (h).	(*See IIUu*)	IIUh Sulphur.	IVUh Strychnine sulphate.	IIIUh Quartz.	VIUh Barium antimonyl dextrotartrate + potassium nitrate.	CUh Cuprite.
Central (c).	IUc Albite.	IIUc Augite.	IVUc Scapolite.	IIIUc Dioptase.	VIUc Apatite.	CUc Iron-pyrites.
Reflected (r).	(*See IBu*)	—	—	IIIUr (Unknown).	—	—
Quarter turn (q).	—	IIUq (Unknown).	—	—	—	—
BILATERAL (B).						
Uniterminal (u).	IBu Clinohedrite.	IIBu Hemimorphite.	IVBu Succinimide.	IIIBu Tourmaline.	VIBu Iodyrite.	CBu Tetrahedrite.
Biterminal						
Central (c).	(*See IIUc*)	IIBc Olivine.	IVBc Idocrase.	IIIBc Calcite.	VIBc Beryl.	CBc Galena.
Reflected (r).	(*See IIBu*)	—	—	IIIBr (Unknown).	—	—
Quarter turn (q).	—	IIBq Copper-pyrites.	—	—	—	—

TABLE II.

Symbol.	System.	Lewis.	Miers.	Symbol.	System.	Lewis.	Miers.
IUu	Triclinic	I	1	IIIUu	Rhombohedral	I	9
IUc	,,	II	2	IIIUh	,,	IV	10
IBu	Mŏnoclinic	II	3	IIIUc	,,	II	15
IIUu	,,	I	4	IIIUr	,,	VI	11
IIUh	Orthorhombic	I	6	IIIBu	,,	V	12
IIUc	Monoclinic	III	5	IIIBc	,,	III	19
IIUq	Tetragonal	VII	22	IIIBr	,,	VII	13
IIBu	Orthorhombic	III	7	VIUu	Hexagonal	I	14
IIBc	,,	II	8	VIUh	,,	V	16
IIBq	Tetragonal	I	26	VIUc	,,	II	17
IVUu	,,	III	21	VIBu	,,	III	18
IVUh	,,	V	23	VIBc	,,	IV	20
IVUc	,,	IV	24	CUu	Cubic	III	28
IVBu	,,	VI	25	CUh	,,	I	29
IVBc	,,	II	27	CUc	,,	IV	30
				CBu	,,	V	31
				CBc	,,	II	32

Professor Miers and Mr. H. Hilton[1]. The latter I had not seen when I read this paper. I recognize the justness of his contention that a centre of symmetry is more fundamental than a plane of symmetry. The chief merit I claim for the present arrangement is that it will be easily apprehended, remembered, and applied by the student. If thought fit Professor Miers's terms 'digonal,' 'tetragonal,' 'trigonal,' 'hexagonal,' and 'tesseral' may be substituted for II-, IV-, III-, and VI-turn, and cubic respectively, and 'di-' prefixed to indicate a bilateral character of the axis. The only difficulty is that some of these expressions have already been widely used in other senses.

By far the most convenient method of referring either viva voce or in writing to any class will be found to be its symbol. Thus quartz may be said to crystallize in IIIUh class; iron-pyrites in the CUc (Cubic Uc) class.

[1] Min. Mag., 1907, vol. xiv, p. 261.

On a Serpentine-rock from the mass of the Tarnthaler-Köpfe, Tirol.

By A. P. Young, Ph. D., F.G.S.

[Read January 29, 1907.]

THE rock-specimens here treated were collected in 1902 on a small plateau near the head of the Oberer-Bach, where the rock is in place. This stream, rising near the Röckner or Reckner, a summit of the Tarnthaler-Köpfe on the north of the Tuxerthaler mass, flows down a steep ravine southward to join the Schmirner-Bach: the locality is situated about 20 kilometres to the south-east of Innsbruck. The figures 2629 (height in metres) on the 'Generalstabskarte' probably represent the site of the plateau; it is on the right bank of the stream, close to, and some 12 or 15 metres above, a small frozen lake near the head of the stream. The point was reached by ascending the ridge from the Kreuzjöchl. There was much snow on the plateau and the geological relations of this particular occurrence were not observed.

The two specimens which I collected on the above-mentioned plateau of the Tarnthaler mass show considerable differences in the proportions of the minerals present. One is rich in colourless pyroxene, and contains but little amphibole and picotite. The other contains much amphibole (probably tremolite), clinochlore, much picotite, and little pyroxene. The conspicuous bastites are more numerous in the rock with much pyroxene. The serpentine-minerals exhibit similar characters in the two specimens.

Pyroxene.—The colourless pyroxene, as seen in thin sections of both the specimens, is remarkable for the complete absence of twinning and zoning. Sections of crystals showing the typical prismatic cleavage give, in convergent light, a positive interference-figure around one of the optic axes, and the optic axial plane is seen to bisect the acute angle between the cleavages. Sections which show the interference-figure of an optic normal give an extinction-angle $c : c = 40°$.

Sometimes the pyroxene forms a core of the larger amphibole crystals to be mentioned below. Inclusions are present in some of the pyroxene crystals; they have the form of short rods arranged in swarms with

their longer axes parallel to the orthopinacoid of the pyroxene, and their refractive index differs but little from that of the host. Or again, some of the pyroxene crystals show undulose extinction; whilst groups of small grains all differing in optical orientation are no doubt in many cases the displaced fragments of a single crystal ('Mörtelstruktur').

This pyroxene seems to be an original consolidation product of the igneous magma, and it resembles the sahlite noted by Hussak[1] in other Alpine serpentines. It has in part been altered to serpentine. Sinuous veins of a pleochroic serpentine traverse the pyroxene crystals in all directions, giving them quite the appearance of decomposing olivines. Only in the absence of iron oxide do these veins differ from those in the surrounding serpentine. The slides were carefully searched for olivine, but this mineral could not be detected[2]. Dull opaque masses of a dark-brown colour and traversed by numerous cracks are not infrequent, and sometimes suggest a derivation from olivine.

Rothpletz[3] records the presence of fresh olivine in the neighbouring serpentine-mass of the Röckner, and von Drasche[4] mentions kernels of the same mineral in serpentinous decomposition products in boulders (which may not, however, belong to this district) at Brixlegg. Reports of other occurrences of olivine in the serpentine-rocks of this district (e.g. at Matrei-am-Brenner and Pfons) appear to be based merely on the structures observed in the serpentinous decomposition products. Seeing, however, how closely the serpentine-veins in decomposing pyroxene crystals may simulate in form the network in altered olivines, the question arises as to how far such conclusions are justifiable.

Amphibole (*Tremolite*).—The mineral is colourless in thin sections, sometimes appearing in compact crystalline form, but more often showing the sheafy habit of secondary amphiboles. The prismatic cleavage is distinctly shown in some of the sections. The needles in the sheaves are sometimes twinned according to (100). Sections showing an emergence of an optic normal have not been found; the highest angle

[1] E. Hussak, 'Ueber einige alpine Serpentine.' Min. Petr. Mitt. (Tschermak), 1883, vol. v, pp. 61–81.

[2] The fact that the pinacoidal cleavage (010) of olivine is perpendicular to the optic axial plane helps to distinguish this mineral from pyroxene; for in sections of the latter, in which the prismatic cleavage is shown as parallel cracks, the trace of the optic axial plane is parallel to these.

[3] A. Rothpletz, 'Ein geologischer Querschnitt durch die Ost-Alpen.' Stuttgart, 1894, pp. 83, 84.

[4] R. von Drasche, 'Ueber Serpentine und serpentinähnliche Gesteine.' Min. Petr. Mitt. (Tschermak), 1872, Jahrg. 1871, pp. 1–12.

of extinction observed is 17°, the axis of less elasticity being nearer the axis of the needle.

The larger crystals of amphibole are traversed by sinuous veins of serpentine, whilst the needles are decomposed at the ends into a bastite-like mineral to all appearance identical with the mineral *A* described below.

The occurrence of amphibole with a core of pyroxene recalls a similar relation in the diabases of Vahrn, near Brixen in southern Tirol. In the tendency to form sheaf-like aggregates the mineral resembles more nearly that of the amphibolites, and is probably to the same extent an original product, either a first crystallization or a very early product of molecular reconstruction in a deep-seated rock-mass.

The decomposition into serpentine-like products proves this amphibole to be older than the serpentine. Lindemann[1] considers an amphibole in a rock of the serpentine group near Sterzing in the Tirol to be secondary and contemporary with the serpentine.

Clinochlore.—A colourless, non-pleochroic mineral of the chlorite group is found only in the slide with much amphibole. It gives low grey polarization-tints and has an index of refraction distinctly higher than that of the serpentines, but lower than that of the amphibole. Twinning with the basal plane as face of composition is frequent. Extinction angles up to 5° have been measured against the trace of (001). The axis of less elasticity is always normal to the cleavage plane, and the 'isogyres' of Becke give indications of a positive optical character for the crystals.

The mineral occurs intimately associated with amphibole, the finer needles of which tend to lie in the plane of cleavage of the clinochlore. The bastite-like mineral accompanying these groups is evidently derived from the amphibole.

Titanite is found in small, angular grains. *Picotite*, in minute grains, is especially abundant in the rock with much amphibole.

Magnetite, in a finely divided state, is disseminated through the rock, accompanying more especially the highly pleochroic serpentine. Higher powers show innumerable trichites and globulites, probably of the same mineral.

Chromic iron-ore may be represented by the dull, opaque masses already mentioned—these never show the forms of chromite; they are probably derived from pyroxene, olivine, or perhaps garnet.

[1] B. Lindemann, 'Petrographische Studien in der Umgebung von Sterzing in Tirol.' Neues Jahrb. Min., 1906, Beilage-Band xxii, pp. 454–554.

Iron-pyrites is found in small quantity in the rock with much pyroxene.

A carbonate, probably *Magnesite*, without twin-lamellae, occurs frequently in both the rock-specimens.

Serpentine-minerals.—The ground-mass in which the above-mentioned minerals are embedded consists of serpentine in two forms: (1) a conspicuously pleochroic mineral, seen most frequently in the veinlets of the net-like structures, and never appearing as compact crystals; (2) a mineral almost colourless in thin sections, often filling the meshes with groups of parallel fibres resembling bastite, and more rarely simulating on a very minute scale the trellis-work figured by von Drasche. This latter form is held to be one of the varieties of serpentine to which the name antigorite has been given, and is here called the 'mineral *A*', the more pleochroic serpentine being called *S*.

A mineral to all appearance identical with *A* is well shown in the section of a rock-specimen from Sprechenstein near Sterzing, Tirol, belonging to my collection of 1905. This specimen furnished the material for the following description of the mineral *A*. The slide contains an abundance of lath-like forms like those represented in von Drasche's fig. 2, and also the pavement or mosaic-structure shown in the same author's fig. 3 [1].

In the Sprechenstein rock the forms in the groups similar to those of von Drasche's fig. 3 show little or no cleavage, whilst with moderately high magnification a very perfect cleavage, like that of the micas, can be recognized in the lath-like forms.

In polarized light the laths present the appearance of twinning after the manner of clinochlore. Extinctions up to 3° have been measured. In convergent light the laths showing the most perfect cleavage give the interference-image of a positive bisectrix with a wide angle of the optic axes: this is probably the acute bisectrix. The negative bisectrix has not been observed.

Individuals showing little cleavage have been found giving the image of an optic axis. The dark bar of the hyperbola appears in this case to be only very slightly curved; the convexity seems to be towards the c bisectrix, again indicating a positive crystal with an axial angle approaching 90°.

The slide of the Sprechenstein rock is too thin to show the pleochroism but pleochroic colours have been observed in the powdered mineral.

[1] These forms are recognized by von Drasche (loc. cit.) to be sections respectively transverse and parallel to the cleavage of the antigorite.

of this rock; bluish-green for vibrations parallel to the cleavage, and brownish-yellow for those transverse to the cleavage. The direction of the bluish-green absorption agrees with that given for antigorite by Hussak and by Weinschenk[1].

It appears from the above that the lath-like forms of the mineral *A* have the characters of individual crystals and not of fibrous aggregates. As regards optical properties, the mineral resembles the biotites, and perhaps some penninites in the optical orientation, the *a* bisectrix being nearly normal to the plane of cleavage. In the low index of refraction, the low double refraction, and the nature of the absorption (the greenish ray vibrating parallel to the cleavage) the mineral resembles the chlorites.

The optical scheme for the mineral *A* given in fig. 1 differs somewhat from that given by Hussak and by Weinschenk for antigorite (fig. 2). Hussak's observations were made on a mineral described as highly pleochroic with leek-green absorption parallel to the cleavage. Weinschenk's mineral was also distinctly pleochroic[2].

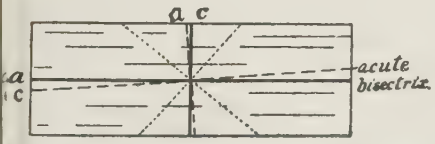


Fig. 1.—Optical orientation of mineral *A*.

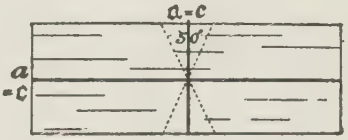


Fig. 2.—Optical orientation of antigorite, according to Hussak and Weinschenk.

The differences can perhaps be explained by supposing the last-named minerals to contain an isomorphous constituent richer in iron oxide, the presence of which determines a wandering of the optic axes towards the *c* axis.

[1] E. Weinschenk, 'Beiträge zur Petrographie der östlichen Centralalpen speciell des Gross-Venedigerstockes.' Abhandl. bayer. Akad. Wiss., 1895, vol. xviii, pp. 651–746. (See p. 661.)

[2] The antigorite of the Antigorio valley diverges in optical properties still more, though in the same direction, from the mineral *A*, the axial angle varying from 0° to 36°. (C. Klein, Sitzungsber. preuss. Akad. Wiss., 1894, p. 768.)

Tschermak gives 20° or more for the axial angle of the Sprechenstein mineral, but says (p. 255), apparently quoting Hussak, 'die kleinste Elasticitätsaxe ist senkrecht zur Spaltebene'—which is, perhaps, a clerical error. (G. Tschermak, 'Die Chloritgruppe.' Sitzungsber. Akad. Wiss. Wien, math.-nat. Classe, 1890, vol. xcix, Abth. I, pp. 174–267.)

In the slides of the Tarnthaler rock the more pleochroic veinlets of the mineral *S* forming the 'network' of the serpentine ground-mass appear to have a slightly higher index of refraction. The polarization-tints are also higher than those of the fibrous mineral in the meshes.

The pleochroism is seen in the thinnest sections, the colours being about the same as in the nearly colourless mineral *A*. The strongest contrast of pleochroic tints is observed when the axis of the vein is respectively parallel and transverse to the principal section of the nicol, being bluish-green for the first and brownish-yellow for the second position. The extinctions also take place in these positions. The axis of greater elasticity is transverse to the axis of the veinlet, coinciding with the yellowish absorption.

The veinlets often show a median longitudinal suture as if they had grown symmetrically by accretion from the walls inwards after the manner frequent in mineral-veins. In polarized light there is often an appearance of fibrous structure, the threads being often at right angles to the walls but occasionally lying obliquely to the walls. There is no break of continuity at the curves of the veinlet. All these facts suggest that the veinlets are built up of ultra-microscopic crystal-elements placed with the axes of elasticity parallel and at right angles to the walls of the veinlets.

It does not appear that the visible fibres represent the ultimate structure of the veinlets of *S*. If it be assumed that these are composed of minute plates of a mica-like mineral with the cleavage planes parallel to the walls of the vein, the mineral will be found to agree in all important respects with the mineral *A*. On this assumption the mineral *S* would approximate closely to the antigorite of Hussak and to that of Weinschenk, both of which are distinctly pleochroic.

Bastite.—Numerous pseudomorphs measuring up to 4 mm. across show the schiller of bastite and are found to resist weathering better than the mass of the rock. On the plateau, where they form numerous prominences on the exposed surfaces, some of these pseudomorphs were seen to be coated with a film of a mineral with bright, silvery lustre.

Sections of these pseudomorphs transverse to the lamellae show, under the microscope, numerous very thin parallel streaks of a mineral with a higher index of refraction and much brighter polarization-tints than those of the antigorite. These streaks, often less than 1 μ and seldom more than 2 μ in thickness, are crowded together to the number of thirty-five or more to the millimetre. The interspaces are filled with

the mineral *A*, usually in the bastite form. Veins of the mineral *A* are seen traversing the pseudomorphs in all directions, independently of the position of the streaks of the more refringent mineral.

The pseudomorphs, consisting mainly of the same material as the ground-mass of the rock, show no very distinct boundaries, especially when the striae are absent.

The mineral composing the striae, really sections of films, shows polarization-tints as high as those of the amphibole, and extinguishes when the striae make a high angle with the principal sections of the crossed nicols. The orientation of the mineral in the films is not known.

It is apparently this mineral which confers the power of resistance to weathering exhibited by these pseudomorphs. A single film cannot be the cause of the silvery reflexions. It is thought that the mineral *A* between the films has been gradually removed by atmospheric influences leading to an accumulation of films by the resulting collapse. The process would go on here with little interruption, as the site is rarely visited.

The bastite pseudomorphs are probably derived from aggregates of the nature of diallage consisting of two minerals in alternating lamellae.

Geologic relations.

A serpentine-rock with olivine has been reported by Rothpletz[1] from the Röckner, close to which is the site of the pyroxene-bearing serpentine here described. This intrusion may thus be compared with those of the Rettenkopf and Todtenköpfe in the Hohe Tauern, described by Becke[2] and Weinschenk[3], and that of the Geisspfad in the Swiss Alps reported by Preiswerk[4], in both of which pyroxene-bearing rocks follow on those rich in olivine.

The serpentine of the Röckner and of the other Tarnthaler summits is found in close proximity to rock-masses showing the typical foliation of the phyllites and containing talc and other magnesian minerals.

The phyllites occupy the crest of the ridge over the chain of frozen

[1] A. Rothpletz, loc. cit.

[2] F. Becke, 'Olivinfels und Antigorit-Serpentin aus dem Stubachthal (Hohe Tauern).' Min. Petr. Mitt. (Tschermak), 1894, vol. xiv, pp. 271–6.

[3] E. Weinschenk, loc. cit.

[4] H. Preiswerk, 'Der Serpentin am Geisspfad (Oberwallis).' Eclogae geologicae Helvetiae, 1901, vol. vii, pp. 123–5.

lakes in the high valley which drains to north and west into the Navis-Thal. They show vertical, plane-parallel joints, which cross the foliation and the axis of the ridge at right angles. The joints are not carried downward into the younger underlying rocks, which include Triassic limestones and the dolomite-breccia of Rothpletz.

The present position of the rocks can only be accounted for by movements of faulting, folding, and overthrust, according to F. E. Suess[1]. According to P. Termier, these rocks form part of a long, recumbent fold[2].

The geologic relations of the Tarnthaler mass show that the intrusion of the serpentines was completed before the commencement of the movements which brought the rocks into their present position. The last great movement was not concerned in producing the foliation of the crystalline schists.

The same relation between serpentine and phyllite is seen to hold at Matrei-am-Brenner and at Pfons, where Blaas traced a complete transition from the ophicalcites and serpentines with little or no foliation to the highly foliated schists.

The masses of the Röckner and of Matrei-am-Brenner are igneous intrusions, the borders of which have been foliated in the same degree as the crystalline schists, whilst the cores have been preserved almost intact. The intrusion of these masses commenced at a period immediately preceding the close of the processes which brought about the foliation of the crystalline schists. The intrusions were continuous and contemporaneous, or nearly so, for margin and core. Before the cores of the masses could be influenced the conditions and activities determining foliation ceased to be effective, and have not since been renewed in this portion of the crust.

[1] F. E. Suess, 'Das Gebiet der Triasfalten im Nordosten der Brennerlinie.' Jahrb. geol. Reichsanstalt, Wien, 1894, vol. xliv, pp. 589-668.

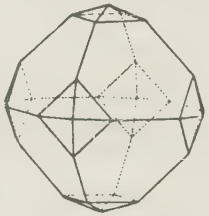
[2] P. Termier, 'Les Nappes des Alpes orientales et la synthèse des Alpes.' Bull. Soc. géol. de France, 1904, sér. 4, vol. iii, pp. 711-65.

Isomorphism as illustrated by certain varieties of Magnetite.

By Professor B. J. Harrington, M.A., LL.D., F.C.S.

[Communicated by L. Fletcher, F.R.S., and read January 29, 1907.]

SOME years ago the writer received from St. Joseph du Lac in the County of Two Mountains, province of Quebec, Canada, a few small specimens of a black mineral which was identified as magnetite. Later, a more careful inspection of the fragments, which weighed from ten to fifteen grams each, showed that some of them were portions of crystals made up of an unusual combination, the octahedron {111} and a trapezohedron {311}. Further, chemical analysis showed that the composition was specially interesting, the mineral being titaniferous and containing, besides 3·24 per cent. of magnesia, a larger proportion of manganese than had been observed in the case of any magnetite previously examined. The crystals displayed no cleavage or parting, but a conchoidal to subconchoidal fracture. Hardness, about 6. Specific gravity (determined with the pycnometer), 4·913. Lustre, metallic and splendent: colour and streak, black. Strongly magnetic. The results of the chemical analysis were as follows:—



Magnetite from St. Joseph du Lac, Quebec: forms {111}, {311}.

		Atomic ratios of metals.	Atomic ratios of oxygen.
Ferric oxide ...	59·71	0·746	1·119
Titanium dioxide ...	5·32	0·066	0·132
Alumina ...	0·62	0·012	0·018
Ferrous oxide ...	22·70	0·315	0·315
Manganous oxide ...	8·46	0·119	0·119
Magnesia ...	3·24	0·081	0·081
Silica	0·16	—	—
	100·21	1·339	1·784

Then dividing respectively by 3 and 4 we get $\frac{1{\cdot}339}{3} = 0{\cdot}445$ and $\frac{1{\cdot}784}{4} = 0{\cdot}443$, the correct ratio for magnetite and other members of the spinel group. It is, of course, unlikely that the titanium exists in the mineral as dioxide; and if it be calculated as sesquioxide and the difference in the oxygen transferred to the iron the analysis becomes:—

		Atomic ratios of oxygen.	
Ferric oxide	65·01 ...	1·219	
Titanium sesquioxide ...	4·79 ...	0·120	1·357
Alumina	0·62 ...	0·018	
Ferrous oxide	17·93 ...	0·249	
Manganous oxide ...	8·46 ...	0·119	0·449
Magnesia	3·24 ...	0·081	
Silica	0·16		
	100·21		

Here the oxygen-ratio for protoxides and sesquioxides ($RO : R_2O_3$) is 0·449 : 1·357, or almost exactly 1 : 3 (1 : 3·022).

Another view with regard to the condition of the titanium in such minerals is that of Mosander, Knop, and others, viz. that it is present as $FeO.TiO_2$ or $FeTiO_3$, which replaces Fe_2O_3 isomorphously. Calculated on this basis the analysis would be:—

		Atomic ratios of oxygen.	
Fe_2O_3 ...	59·71 ...	1·119	
$FeTiO_3$ ...	10·11 ...	0 199	1·336
Al_2O_3 ...	0·62 ...	0·018	
FeO ...	17·91 ...	0·249	
MnO ...	8·46 ...	0·119	0·449
MgO ...	3·24 ...	0·081	
SiO_2 ...	0·16		
	100·21		

Here the ratio for RO to R_2O_3 (including $FeTiO_3$ with the latter) is also practically 1 : 3 (1 : 2·975). Knop[1], who made a study of octahedrons of titaniferous magnetite yielding on analysis 24·95 per cent. of TiO_2, favoured the last view as to constitution; for here if the titanium were calculated as Ti_2O_3 the ratio of $RO : R_2O_3$ was 1 : 1·165, while if $FeTiO_3$

[1] A. Knop, 'Ueber titansäurehaltigen Magneteisenstein.' Annalen der Chemie (Liebig), 1862, vol. cxxiii, pp. 348–53.

were regarded as replacing Fe_2O_3 the ratio became a normal spinel ratio. In all such cases, however, the question of the distribution of the oxygen is largely speculative, and the really significant ratio is that between the metals and oxygen as a whole. There is no probability whatever that in the case of the St. Joseph du Lac crystals the titanium is present in the form of intermixed rutile. Owing to the exceptionally large proportion of manganese the mineral may be regarded as intermediate between magnetite proper and jacobsite.

The form {311}, which is rare in magnetite, occurs also in spinel and other members of the group, including gahnite, franklinite, and chromite. It is very well developed in some of the spinel crystals from Amity and Monroe in New York State.

Since writing the above, the writer has paid a hurried visit to St. Joseph du Lac in the hope of discovering the exact locality from which the magnetite crystals were obtained. The person who had found them having died some time before, no definite information as to the exact spot was available, but some of the farmers of the district had long known of a massive magnetic ore occurring in connexion with crystalline limestone on Lot 71 of the Parish of Oka. This spot was visited and specimens of the ore obtained. They are black in colour and streak, less brilliant in lustre than the crystals described above and not quite so strongly magnetic. The specific gravity of a fragment was found to be 4·61, and a partial analysis proved that the mineral in addition to being titaniferous also contains considerable quantities of manganese and magnesia, the percentages of these three constituents being as follows:—

Titanium dioxide	...	6·94
Manganous oxide	...	3 90
Magnesia ...	...	5·58

The composition, in a general way, therefore, is similar to that of the crystals, and it is not unlikely that a more careful examination of the region would result in the discovery of the original locality.

The late Professor Penfield of Yale having called the writer's attention to the fact that magnetite crystals from Magnet Cove, Arkansas, also exhibited the combination {111}, {311} (with rhombic-dodecahedral faces in some cases), specimens from this locality, which have been for many years in the mineral collection of McGill University, have been submitted to chemical analysis in order to ascertain whether similarity of form was accompanied by closely related composition. The results, however, show that in the latter respect they differ decidedly from the

Canadian mineral. The Magnet Cove crystals lack the freshness and brilliancy of those from St. Joseph du Lac. Their hardness is about 6, and specific gravity 4·558. Lustre, metallic. Colour black and streak blackish-brown. Attracted by the magnet, though not so strongly as in the case of the mineral already described. The fine powder was not completely soluble in hydrochloric acid at ordinary pressures, but it dissolved completely on heating with hydrochloric acid in a sealed tube for several hours at a temperature of 150° C. The ferrous oxide was determined by decomposing in this way and titrating with potassium dichromate. The mineral was also completely decomposed by fusion with sodium disulphate. Quantitative analysis gave the following results:—

		Atomic ratios of metals.	Atomic ratios of oxygen.
Ferric oxide ...	59·01	0·739	1·106
Titanium dioxide ...	2·40	0·030	0·060
Alumina	10·37	0·203	0·304
Ferrous oxide ...	16·82	0·234	0·233
Manganous oxide ...	2·10	0·030	0·029
Magnesia	9·47	0·237	0·236
	100·17	1·473	1·968

Here, again, the ratio for metals to oxygen is the normal one, as will be seen by dividing respectively by 3 and 4: $\frac{1\cdot473}{3} = 0\cdot491$, and $\frac{1\cdot968}{4} = 0\cdot492$.

If, as in the last case, the titanium be calculated as Ti_2O_3 the analysis becomes:—

		Atomic ratios of oxygen.	
Ferric oxide ...	61·41	1·151	
Titanium sesquioxide	2·16	0·045	1·500
Alumina	10·37	0·304	
Ferrous oxide ...	14·66	0·204	
Manganous oxide ...	2·10	0·029	0·469
Magnesia	9·47	0·236	
	100·17		

Here the ratio for $RO : R_2O_3$ is 1 : 3·19 instead of 1 : 3, possibly indicating alteration and change in the distribution of oxygen between the ferrous and ferric iron. The alumina was determined by difference

in the usual way and not directly. The large proportion of this constituent and of the magnesia indicate a mineral intermediate in composition between magnetite and spinel[1].

A third specimen of crystallized magnetite has also been examined, in order to ascertain whether its composition was exceptional. It came from Digby, Annapolis County, Nova Scotia, where it is said to occur in veins in the trap-rocks of the region. The crystals are about three-quarters of an inch in diameter and composed of two forms {111} and {110}. In no case has the trapezohedron been observed. The specific gravity was found to be 5·067, and chemical analysis gave the following results :—

		Atomic ratios of metals.	Atomic ratios of oxygen.
Ferric oxide ...	70·64	0·883	1·324
Titanium dioxide ...	0·24	0·003	0·006
Ferrous oxide ...	26·13	0·363	0·363
Manganous oxide ...	trace	—	—
Magnesia	2·97	0·074	0·074
Silica	0·03	—	—
	100·01	1·323	1·767

Dividing by 3 and 4, we have $\frac{1\cdot323}{3} = 0\cdot441$ and $\frac{1\cdot767}{4} = 0\cdot441$, exactly the normal ratio for magnetite. As in the former cases, no lime was found, but magnesia was again present, no doubt replacing ferrous oxide.

The analyses given in this paper do not establish any definite relationship between crystalline form and chemical composition in magnetite, but are offered as a contribution to the study of isomorphism as occurring in this important species.

Department of Chemistry and Mineralogy,
McGill University, Montreal.

[1] Many years ago Professor G. A. Koenig examined nodular masses of magnetite from Magnet Cove and found them to be titaniferous and also to contain a little vanadium ($V_2O_3 = 0\cdot17$). It was the writer's intention to examine the crystals for vanadium, but owing to want of time this has not been done. For Professor Koenig's analysis see Proc. Acad. Nat. Sci. Philadelphia, 1877, p. 293.

Baddeleyite from Ceylon.

By G. S. Blake, A.R.S.M., B.Sc., F.C.S.
Assistant in the Scientific and Technical Department of the Imperial Institute.

And G. F. Herbert Smith, M.A., D.Sc., F.G.S.
Assistant in the Mineral Department of the British Museum.

[Read March 19, 1907.]

DURING recent years a systematic survey of the mineral resources of Ceylon has been in progress, in connexion with which a large number of specimens have been sent to the Imperial Institute for examination. In 1905 several cases containing coarse gravel from the streams of the gem-district of Balangoda were received. The constituent minerals were mainly zircon, tourmaline, corundum, spinel, ilmenite, together with small quantities of geikielite[1], fergusonite, and other rare-earth minerals. Last summer during the examination of these gravels one of the authors found three black crystals with unusually brilliant faces. The apparently monoclinic form and the general physical characters at once suggested the crystallized native zirconia, baddeleyite, and this conjecture was confirmed by the goniometrical measurements and the chemical analysis.

It is of interest to note that prior to this discovery there is no record of a specimen of this mineral being found in the island since Mr. L. Fletcher[2] first determined, fifteen years ago, not only the crystallographical but also the chemical properties of this species by means of an investigation of a single rough crystal, now exhibited in the Mineral Gallery of the British Museum. This crystal was included among a lot of specimens of heavy minerals which had been collected by Mr. Joseph Baddeley at Rakwana, Ceylon, and brought by him to England. Mr. Fletcher detected the crystal when picking out specimens of the then new mineral, geikielite,

[1] T. Crook and B. M. Jones, 'Geikielite and the ferro-magnesian titanates.' Min. Mag., 1906, vol. xiv, pp. 160–6.

[2] Nature, 1892, vol. xlvi, p. 420. L. Fletcher, 'On baddeleyite (native zirconia), a new mineral, from Rakwana, Ceylon.' Min. Mag., 1893, vol. x, pp. 148–60.

which Mr. Baddeley had courteously offered to the Museum. Crystals of baddeleyite have been found in abundance by Dr. E. Hussak in the magnetite deposits at Jacupiranga, São Paulo, Brazil, and his description[1] of them was published almost simultaneously with Mr. Fletcher's paper.

(a) *Crystallographical Characters.*

Of the three crystals mentioned above, one was broken at both ends and displayed the prism-zone only; it was used for the chemical analysis Each of the remaining crystals possesses faces at one end. One (fig. 1) is a twin of the common type with a (100) as the plane of twinning; of the two individuals, one has the forms $a\{100\}$, $b\{010\}$, $m\{110\}$, $d\{021\}$, $r\{\bar{1}01\}$, $a\{\bar{2}01\}$, and $n\{\bar{1}11\}$, and the other $a\{100\}$, $b\{010\}$, $c\{001\}$, $m\{110\}$, $d\{021\}$, and $n\{\bar{1}11\}$. Contiguous faces of the form $d\{021\}$ on the two individuals meet in a re-entrant angle. The crystal measures approximately 5 mm. in length, 8 mm. in width, and 4 mm. in thickness,

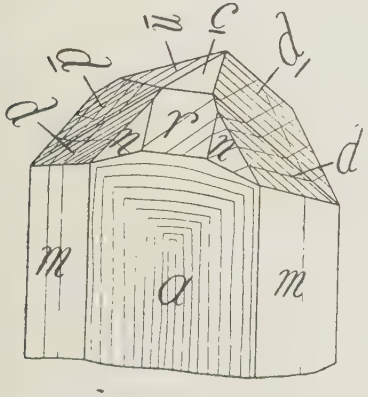


Fig. 1.

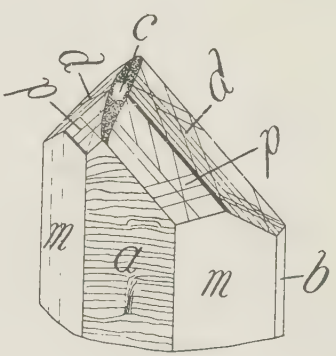


Fig. 2.

Baddeleyite from Ceylon (twinned and simple crystals).

and it weighs 0·695 gram. The other (fig. 2) is a simple crystal and untwinned. It is remarkable how rare such crystals are; out of some

[1] E. Hussak, 'Über Brazilit.' Neues Jahrb. Min., 1892, vol. ii, pp. 141-5; 'Ueber den Baddeleyit (syn. Brazilit) von der Eisenmine Jacupiranga in São Paulo.' Min. Petr. Mitt. (Tschermak), 1895, vol. xiv, pp. 395-406. The name 'brazilite' was withdrawn by Dr. Hussak.

hundreds of crystals isolated by him, Dr. Hussak[1] found only three which were not twinned, and the crystal described by Mr. Fletcher also is twinned. The simple crystal displays the forms $a\{100\}$, $b\{010\}$, $c\{001\}$, $m\{110\}$, $g\{210\}$, $d\{021\}$, $t\{101\}$, and $p\{221\}$. It measures approximately 9 mm. in length, 7 mm. in width, and 3 mm. in thickness, and weighs 0·775 gram. As shown in the drawing, the top is slightly broken. Both crystals are striated in such a way as to indicate polysynthetic twinning with respect to both a (100) and m (110), a character remarked by Dr. Hussak on the Brazilian crystals and fully described by him. Both are black in colour, and sub-metallic and opaque in appearance. In thin splinters, however, the substance is seen to be transparent and yellowish in colour.

The forms observed, eleven in number, and their characters are as follows:—

$a = \{100\}$ large; striated irregularly: good reflexions.

$b = \{010\}$ small.

$c = \{001\}$ not large; slightly uneven.

$m = \{110\}$ large; striated parallel to the prism-edge: reflexions good.

$g = \{210\}$ large on the simple crystal (at the back as shown in fig. 2), otherwise small; sometimes forms the sides of pittings on a (100): reflexions poor.

$t = \{101\}$ small.

$r = \{\bar{1}01\}$ small: only once observed.

$o = \{\bar{2}01\}$ minute.

$d = \{021\}$ large; striated: reflexions good.

$p = \{221\}$ large; striated: reflexions good.

$n = \{\bar{1}11\}$ not large; striated: reflexions good.

The form $g = \{210\}$ has not been recorded before.

The notation and parameters of Dr. Hussak have been adopted in this paper. Mr. Fletcher selected a slightly different parametral plane; his (hkl) is equivalent to $(h.k.2l)$ of Dr. Hussak.

Both crystals were measured on the three-circle goniometer in the British Museum from the faces of the form $a\{100\}$, which despite the markings on them invariably gave well-defined reflexions, as origin, and the measurements with the corresponding calculated values are given in the following table:—

[1] Min. Petr. Mitt. (Tschermak), 1894, vol. xiv, p. 399.

TABLE I.

Measurements from a = (100).

Form.		Calculated Values.		Observed Values.			
				Twinned Crystal.		Simple Crystal.	
		Azimuth.	Distance.	Azimuth.	Distance.	Azimuth.	Distance.
c	001	90° 0′*	80° 32′	90° 0′	80° 32′	89° 56′	80° 23′
t	101	,, ,,	55 24½	...	...	,, ,,	55 10
r	10$\bar{1}$	,, ,,	−70 23½	90 0	−70 37		
a	20$\bar{1}$	,, ,,	−47 54	,, ,,	−47 54		
n	11$\bar{1}$	62 56	−72 24	62 57	−72 14		
				62 53	−72 9		
				62 55	−72 2		
d	021	44 23*	83 21	44 17	83 31	44 14	83 18
				44 26	83 27	44 33	83 16
				44 27	83 21		
				44 22	83 13		
p	221	,, ,,	49 41½	...	...	44 14	49 44
						44 33	49 35
b	010	0 0	90 0*	0 0	89 59	0 0	89 53
				,, ,,	89 43		
m	110	...	44 20*	,, ,,	44 27	,, ,,	44 19
				,, ,,	44 14	,, ,,	44 26
				,, ,,	44 12	,, ,,	44 24
				,, ,,	44 24	,, ,,	44 14
g	210	...	26 2	...	...	,, ,,	26 0
							26 3
							26 2

The angles from which the calculations have been made are indicated by asterisks.

The calculated coordinates of the observed forms with respect to the face of symmetry *b* = (010) as origin are tabulated below :—

TABLE II.

Coordinates from b = (010).

$a:b:c = 0{\cdot}9905:1:0{\cdot}5110$; $\beta = 99°\,28'$.

Form.		Azimuth.	Distance.
r	$\bar{1}01$	$-70°\ 23\frac{1}{2}'$	90° 0′
n	$\bar{1}11$	,, ,,	64 18
c	001	80 32	90 0
d	021	,, ,,	44 $46\frac{1}{2}$
t	101	55 $24\frac{1}{2}$	90 0
p	221	39 $30\frac{1}{2}$	56 $58\frac{1}{2}$
a	100	0 0	90 0
g	210	,, ,,	63 58
m	110	,, ,,	45 40
b	010	,, ,,	0 0

The crystals are unusually large, and their faces unusually plane for this mineral; Dr. Hussak, indeed, found crystals measuring as much as 5 mm., but owing to the distortion of the faces they were quite useless for purposes of measurement, and Mr. Fletcher's crystal also gave very ill-defined reflexions. The measured values in the prism-zone agree closely with those recorded by Dr. Hussak; but in the zone of symmetry [*ac*] there is an appreciable difference between the values observed on these crystals and those noted by Dr. Hussak. The following table compares the observed values in the two cases:—

	Hussak.	Smith.
$am = (100):(110)$	$44°\ 17\frac{1}{2}'$	$44°\ 20'$
$ac = (100):(001)$	81 $14\frac{1}{2}$	80 32
$ar = (100):(10\bar{1})$	69 41	70 37
$at = (100):(101)$	55 51	55 $24\frac{1}{2}$

Dr. Hussak found as the limiting values for the angle $ac=(100):(001)$ $80°\ 56\frac{1}{2}'$ and $81°\ 42'$, so that the measurements in the present case lie well outside this range.

On the other hand, the values calculated from the fundamental angles selected in this paper accord in certain cases better with Dr. Hussak's observations than do his own calculated values; thus:—

	Hussak. Observed.	Hussak. Calculated.	Smith. Calculated.
$an = (100):(11\bar{1})$ . . .	72° 16′	71° 45½′	72° 24′
$ap = (100):(221)$ . . .	49 40½	50 41	49 41½
$ad = (100):(021)$ . . .	83 28	83 51	83 21

There is a noticeable variation in the specific gravity, which is comparable with, though not so great as, that observed in the case of zircon. Mr. Fletcher gives 6·025 as the value for the crystal examined by him, whereas Dr. Hussak obtained 5·5 for the Brazilian crystals. In the case of the present crystals, the specific gravities of the crystal used in the analysis and of the twinned crystal are 5·72 and 5·73 respectively, while for the simple crystal it is as much as 5·82.

(b) *Chemical Examination.*

The crystal which was utilized for the determination of the chemical composition weighed 0·6413 gram, and had a specific gravity of 5·72. It was ground to a powder and fused for several hours with potassium hydrogen sulphate. The resulting mass was dissolved in water, and the silica in the small amount of insoluble residue determined. The hydrochloric acid solution of the bases, freed from potassium sulphate, was treated with ammonium oxalate, and it was found that the thorium and cerium metals were absent. The ammonium oxalate was removed, and sodium thiosulphate was added to the nearly neutral solution. The amount of iron in the filtrate was determined. The precipitate, which consisted presumably of zirconium thiosulphate, was converted into hydroxide and weighed as oxide. The precipitate was re-dissolved and tested for uranium and titanium, but a trace of the latter element only was detected.

The following are the results of the analysis (G. S. B.):—

Zirconia, ZrO_2	98·90
Ferric oxide, Fe_2O_3 / Ferrous oxide, FeO	0·82
Lime, CaO	0·06
Silica, SiO_2	0·19
Loss on ignition.	0·28
	100·25

The following are the characteristic reactions of the principal element in the mineral :—

(*a*) From a solution, ammonium oxalate precipitates the oxalate, which is readily soluble in excess of the reagent, either acid or neutral;

(*b*) Sodium thiosulphate precipitates it from neutral solutions;

(*c*) The neutral sulphate forms an insoluble double salt with potassium sulphate.

These reactions suffice to group the element with thorium, zirconium and titanium. The proof that it is actually zirconium was sought for by the preparation of the fluoride. The oxide obtained from the analysis was dissolved in hydrofluoric acid and the solution slowly evaporated in a covered platinum crucible with the formation of colourless, transparent crystals, which were dried first on filter-paper, and then for two days *in vacuo* over calcium chloride. The crystals have the triclinic symmetry described by Marignac[1], but were not well developed. It was found that 0·3000 gram of this salt yielded 0·1638 gram of the oxide. If the composition be assumed to be $ZrF_4.3H_2O$, the element would have an atomic weight of 91, which is so near that determined for zirconium, viz. 90, as to justify the inference that the oxide contained this element alone of the group given above.

The chemical analysis of the mineral has been further confirmed by a spectroscopic examination, which was undertaken by Mr. A. Fowler at the Royal College of Science, London. The arc-spectrum was photographed with an instrument of high dispersion, and a comparison with the tables of Exner and Haschek in the region of 4367 to 4689 shows all the lines of zirconium recorded by those observers with the exception of one at 4408·54. The only additional strong line in this part is at wave-length 4602·73. The spectrum, however, was found to be identical with that given by a portion of a crystal of common zircon, except that the baddeleyite showed a slight trace of manganese in addition to iron.

[1] Annales chim. phys., 1860, sér. 3, vol. lx, pp. 266–7.

On the occurrence of silver ore in the Perran mine, Perran Uthnoe, Cornwall.

By Francis H. Butler, M.A., A.R.S.M., L.S.A. (Lond.).

[Read March 19, 1907.]

THE deposit known as the Wheal Sedgman lode is inclined to the west a few degrees from the vertical, and runs in a direction about 10° W. of N. (magnetic) through the parish of Perran Uthnoe, near Marazion, Cornwall. In its course seawards from the approximately E. and W. lode formerly worked in the Great Wheal Neptune mine, it traverses the North and South Trebarvah tin and copper lodes. It is crossed by the shore-line on Perran Sands, about 500 yards to the west of Trevean cliff. Between that spot and Cuddan Point, to the S.E., where it is again laid bare, it has been superficially removed by marine denudation. The numerous N. and S. diabase dikes of the district show in places much disseminated pyrrhotite, and one of them runs nearly parallel to the east side, or foot wall, of the Sedgman lode. The bed-rock of the district is a pyritous bluish killas, which, where it forms the 'country', or walls adjoining the lode, is finely laminated and very variable in hardness, being occasionally represented at its junction with the lode by a clay. In breadth the Sedgman lode varies from 6 feet to 18 inches. In the northern part it consists of a series of roughly parallel bands of quartz and chalybite. The quartz is crystalline and of a pure white, and carries a little bright mispickel, with blende, pyrite, and chalcopyrite. The chalybite is externally pale buff and internally nearly white, and contains some cavities enlarged by aqueous erosion without oxidation and others lined with lenticular crystals of the same mineral. This spathic and wide portion of the lode is practically non-argentiferous, the chalybite containing only half an ounce of silver to the ton: the invariable experience, as Mr. G. D. McGrigor informs me, is that where there is chalybite, there is no silver ore. The Sedgman lode within 200 yards to the south of the Great Wheal Neptune deposit consists of more or less argentiferous, friable, and ochreous or harder, chocolate-coloured, and quartzose

limonite with parallel seams of ferruginous, highly compact, splintery quartz, which passes into crystalline quartz only in the less argentiferous parts of the lode. This quartz (locally called the 'cab-course') is found to be best developed where the limonite is richest in cerargyrite, the prevalent silver ore, although this mineral has only once been observed implanted on hard quartz.

The amount of silver obtained in driving on the course of the lode to a depth as yet not exceeding 18 fathoms has varied from over 11,000 to as little as 2 ounces to the ton of limonitic ore. In proportion as the workings have been carried south, the richest ore has been discovered progressively deeper; i. e. the line of most complete silverization, or secondary enrichment, of the original lode corresponds roughly to that of the contour or shoreward trend of the overlying land. This fact illustrates the remark of the late J. G. Goodchild[1] that, speaking generally, one may say that around certain points where the occurrence of ore in any given set of veins reaches a maximum elevation above the sea, the upper limit of occurrence of the ore in the several veins falls successively to lower and lower levels in proportion to their distance from those highest points. He further makes the interesting observation, in dealing with the North of England lead-veins, that 'the parallelism between the deep-seated phenomena and the surface features points to former variation in the downward increment of temperature connected with the shape of the ground when the veins were formed'.

In the Sedgman lode it is the lower and more friable, or gossany, limonite that has proved the more argentiferous. Another noteworthy fact is that the deposition of hornsilver has been greatest at irregular intervals along oblique lines having a sharp slope seawards. In consequence, within a few feet in depth, the richer ore may appear on opposite sides of a narrow shaft.

Besides cerargyrite, no other silver ores have so far (March 1907) been found in the Perran mine, save a little galena, a few ounces of massive argentite, forming a nucleus of the ordinary lode-stuff, and a small specimen of wire-like native metal. The cerargyrite occurs either intimately mixed with the limonite and crystallized in usually much distorted small cubes and cubo-octahedra upon its free surfaces or in malleable and sectile masses from an ounce or two to several pounds in weight. Of numerous analysed examples of the cerargyrite not one has yielded more than traces of bromine.

[1] J. G. Goodchild, 'Some observations upon the mode of occurrence and the genesis of metalliferous deposits.' Proc. Geol. Assoc., 1889, vol. xi, pp. 45–69.

Visible cassiterite has been come upon twice in the working of the lode, and the refuse from the dressing of the ore has been found to contain about 0·1 per cent. of 'black tin'. There is evidence also that the ore contains some 5 grains of gold to the ton.

History of the Lode.—On examination of the lode and of hand-specimens therefrom it becomes patent that, as with Cornish mineral-veins in general, siliceous solutions were largely concerned both in the production of the original Perran deposit, and in bringing about modifications therein. What such solutions can effect is well exemplified in various districts in the west of England, e.g., in the production of the greisen of the Bunney mine and of the Rock Hill clay-pit, in St. Austell parish, of Kit Hill, and of Cligga Head. There broad or narrow courses of granite in the direction of planes of fracture have been first kaolinized and then deprived of their kaolin and furnished with fresh quartz, varying quantities of secondary mica, commonly much schorl, cassiterite crystals, and occasionally fluor. In the northern part of the Sedgman lode, the alternation of bands of chalybite and quartz, the presence of slickensides one behind another, and the inclusion in the chalybite of fragments of brecciated killas testify that the original fissure was enlarged and gradually filled during a succession of earth-movements. The normal tints of the chalybite and quartz here found and the unmodified condition of their disseminated mineral contents indicate that any lode-water that may have reached them after deposition was free from oxidizing agents. The blueness of the neighbouring killas points to the same conclusion.

The fissure having been occupied by chalybite and quartz, the chalybite along a considerable extent of the lode, but not in the northern part, was subjected to the action of a siliceous solution that contained a limited supply of available oxygen, but was rich in silver and in chlorine, the last-named element possibly owing its presence to the access of sea-water to abyssal regions. It is interesting to note in this connexion that the multitudinous fluid-containing vesicles of the quartz of a fluor-kaolin-rock in a quarry between Nanpean and Trethosa, in Cornwall, near the Mineral Railway, mostly contain each a cube of salt besides the usual bubble. The effect of the second aqueous invasion of the Sedgman lode was largely to decarbonate, hydrate, and oxidize the chalybite in its southern portion, forming limonite, to add considerably to the quartz already there existing, and to cause the irregular deposition of silver chloride in cavities and on free surfaces. Why the lode was not similarly attacked in its whole length might be as difficult

to explain as the sporadic kaolinization of granite that is observable in some of the St. Austell clay-pits.

Since, in the alteration of chalybite to limonite, four molecules of carbon dioxide became nascent for every molecule of oxygen taken out of solution, the vein-water was rendered a powerful solvent of the residual chalybite. That it had been deprived of any available oxygen it may originally have contained is evidenced by the lack of adventitious superficial coloration of the quartz in some of the cavities in limonite from the interior of which chalybite has been removed, and also by the fresh and unaltered condition of the surface of masses of chalybite still in part occupying other of those cavities. The ultimate oxidation of ferrous carbonate dissolved out of the lode may account for much of the ferruginous staining and cementation of the rubbly and brecciated material at its out-crop.

The cassiterite of the lode is possibly of late origin in its history, and may have been derived from the source of supply of the E. and W. lodes of the district of Perran.

For free access to the Perran mine and its products during the preparation of this paper, I am indebted to the courtesy of the managing owner, Mr. G. D. McGrigor.

Communications from the Oxford Mineralogical Laboratory. No. IX.

On Hamlinite from the Binnenthal, Switzerland.

By H. L. Bowman, M.A., F.C.S.

Demonstrator of Mineralogy in the University of Oxford.

[Read June 11, 1907.]

In a paper read before this Society in 1904 [1], dealing with a number of new minerals from the Binnenthal dolomite, Mr. R. H. Solly described under the name of bowmanite some small, honey-yellow crystals belonging to the rhombohedral system and forming either hexagonal plates or combinations of rhombohedron and basal planes of octahedral habit. Mr. Solly afterwards handed over the small amount of available material to me for further examination.

In density, hardness, cleavage, habit, and sign of birefringence, the crystals were found to resemble hamlinite, the phosphate of aluminium and strontium, described by W. E. Hidden and S. L. Penfield [2] from the herderite locality at Stoneham, Maine, and later by Penfield [3] from Oxford Co., Maine. They differed from this mineral, however, in being pseudo-hexagonal—the hexagonal plates showing a division into biaxial sectors, while hamlinite from Stoneham was stated to give a perfectly normal uniaxial interference-figure.

The quantity of material (amounting only to a few milligrams) was too small to admit of an analysis being made, but from qualitative tests of a few minute grains, the mineral appeared to be a phosphate of lime and alumina, with small amounts of iron, water, and possibly magnesia. [In the light of later work, however, it seems probable that the calcium and magnesium found here may have been derived from traces of dolomite.

Since that time Mr. Solly has kindly obtained for me some more specimens, found in 1905 and 1906, so that I have been enabled to make a more detailed study of the mineral and to collect sufficient pure material for some quantitative experiments, which have resulted in its identification with hamlinite.

[1] Min. Mag., 1905, vol. xiv, pp. 72–82.

[2] Amer. Journ. Sci., 1890, ser. 3, vol. xxxix, p. 511.

[3] Ibid., 1897, ser. 4, vol. iv, p. 313.

Occurrence.—The crystals, which rarely exceed 1 mm. in diameter (the largest I have seen being a hexagonal plate 1·3 mm. in diameter and 0·7 mm. in thickness), and are usually much smaller, occur on the surface of cracks and cavities in the white dolomite, associated with hyalophane, colourless crystals of barytes, and modified rhombohedra of dolomite, often lining the surface; sometimes also small, colourless crystals of quartz and minute, black crystals of rutile. The dolomite is generally rich in brown flakes of biotite and often contains granular iron-pyrites, while crystals of blende and iron-pyrites are also present on some specimens. In one case, some crystals of hamlinite are scattered over the surface of a rough prism of rathite. Perfect, symmetrically-developed crystals of hamlinite frequently occur embedded loosely in a white, powdery material, from which they are easily freed by rubbing between the fingers.

Crystalline Form.—The crystals are very simple, the only forms observed being $c\{111\}$ and $r\{100\}$, of varying relative sizes, sometimes with minute faces of $f\{11\bar{1}\}$ on the edges or corners.

Two types of habit may be distinguished, viz. (1) flat hexagonal plates with modified edges, sometimes aggregated in rosettes, and (2) stouter crystals showing the unit rhombohedron and resembling either octahedra or cubes according to the size of the faces of $c\{111\}$.

The crystals are generally very symmetrically developed, but the faces are almost always uneven and do not yield good reflexions of the signal. Measurements between faces giving only single images, on four tabular crystals, gave values varying between 53° 44′ and 55° 49′ for the obtuse angle *cr*, and between 123° 44′ and 125° 52′ for the corresponding acute angle, the means being 54° 58½′ and 125° 4½′ respectively.

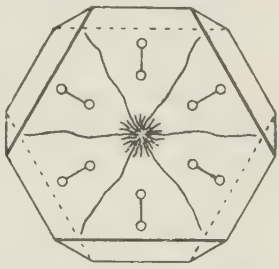
This agrees well with the measured angle found by Penfield (about 55°), though the angle adopted by him (calculated from $rr = 87° 2'$) was $cr = 52° 40'$.

There is a good cleavage parallel to $c\{111\}$.

The colour varies considerably, crystals ranging from nearly colourless to reddish-brown. The flat, hexagonal crystals are characteristically pale in colour with a brown spot in the centre.

Optical Properties.—Some of the smaller, tabular crystals appear isotropic under the microscope (except at the extreme edges), and in convergent light show a normal uniaxial interference-figure, with moderately weak, positive birefringence; but larger ones always show a division into six, more or less regular, triangular, biaxial sectors, which possess weak birefringence compensated by a quartz-wedge inserted

radially. The sectors are separated by wavy, dark lines along which, and also at the centre of the crystal, the interference-figure is uniaxial (see fig.). The sectors extinguish together in pairs, roughly parallel to the corresponding edge of the hexagon, and each gives a positive biaxial figure with the axial plane nearly perpendicular to that edge. The axial angle (2E) varies from 0° up to about 50°.



Optical orientation of hamlinite from the Binnenthal.

Thus the crystals are pseudohexagonal, the variation in the optical properties being due to the overlapping of twin-lamellae parallel to the cleavage, as in the case of the micas, chlorites, &c.

The angles between the edges of the hexagonal plates do not appear to be exactly 60° (values were observed varying between $58\frac{1}{2}°$ and 62°), while the extinction-directions in the sectors are frequently not quite parallel to the edges, but deviate sometimes as much as 5° from this position, and on adjacent sectors include angles of 57°–63°.

The symmetry of the component crystals may thus be lower than that of the orthorhombic system, but the observations are not sufficiently concordant to warrant any definite conclusions being drawn from them.

The darker (reddish-brown) crystals are slightly pleochroic, when viewed along the plane of cleavage, vibrations parallel to the cleavage (ω) being reddish-brown, while those perpendicular to it (ϵ) are yellow.

Specific Gravity.—The density of twelve selected crystals, apparently quite pure, was determined by means of methylene iodide and a Westphal's balance, and found to vary from 3·219 up to 3·266. That of hamlinite from Stoneham is given as 3·228, while the crystals from Oxford Co. analysed by Penfield varied between 3·159 and 3·283.

The hardness is about 4 or rather more.

Chemical Composition.—The mineral is insoluble in hydrochloric acid, as sharp crystals, after boiling with the acid, showed under the microscope no sign of being attacked and were unchanged in colour; they are, however, readily decomposed on fusion with alkaline carbonates.

The results of a preliminary examination, made on 0·0659 gram of slightly impure material, which proved to contain about 6 per cent. of silica (probably from admixed hyalophane), are given in column I of the table. The powder (dried at 98° C.) was ignited in a platinum crucible to constant weight. It was then fused with alkaline carbonates, dissolved in nitric acid, and the phosphoric acid precipitated (after

separation of the silica) by ammonium molybdate and weighed as magnesium pyrophosphate. The estimation of alumina and the other constituents could not be carried out owing to the presence of impurities in the ammonium molybdate used.

An attempt was then made on the main portion of pure material (0·1127 gram) to determine the water directly by Penfield's method (column II). The powder was heated to low redness in a boat of platinum-

	I.	II.	III.	IV.	Penfield.
P_2O_5	24·2	26·1	...	...	30·31
Al_2O_3	...	35·6	...	...	32·65
SrO	...	...	19·2	20·5	19·29
BaO	...	...	0·2	0·1	4·08
H_2O	...	[12·4]	...	...	12·48
F	...	...	...	...	2·04
Loss on ignition	15·6	[12·9]	15·6	16·0	
K_2O	...	...	...	0·4	
SiO_2	5·9	3·8	0·9	0·7	
Insoluble in HCl	...	...	2·1	...	

foil, and the water found amounted to 12·4 per cent., while the loss of weight of the boat was 12·9 per cent. The water was markedly acid, and probably contained a little hydrofluoric acid, as the glass was slightly attacked and the outside of the boat showed a slight deposit of silica. The cause of the low value here obtained is probably an insufficiently high temperature, as it was afterwards found that intense ignition was required to drive off the last portions—whether of water or fluorine. Owing to the small amount of material available, no attempt has been made to determine the proportions of these two constituents.

The silica and phosphoric acid were determined as before. The figure for alumina is probably not very reliable, owing to the difficulty of separating it from the large amount of molybdic acid present.

As the numbers so far obtained approximated to those given by Penfield for hamlinite from Oxford Co., Maine (quoted in the last column), I made a direct test for barium and strontium, without previous separation of phosphoric acid.

Columns III and IV give the results of two determinations made with 0·0340 and 0·0568 gram respectively of a fresh sample of material. They may not therefore be quite comparable with the previous determinations. The loss of weight was determined in a platinum crucible and

was found to be complete only after long and intense ignition. The powder, which was found to be slowly soluble after ignition, was dissolved in hydrochloric acid, the silica separated by evaporation in the usual way, and barium and strontium then precipitated as sulphates. On applying Fresenius's method of separation by double precipitation with ammonium chromate, as used by Penfield for hamlinite, barium was found to be present only in traces.

Considering the small amount of material used, the agreement with Penfield's numbers for hamlinite, when taken in connexion with the similarity in crystalline characters, appears to be sufficiently close to prove the identity of the two minerals. The difference in the optical characters is only such as might be expected in a pseudosymmetric substance, and may possibly be connected with the difference in the mode of occurrence,—the hamlinite from Maine being found in granitic rock, associated with herderite and bertrandite.

A (fourth) list of new mineral names[1].

By L. J. Spencer, M.A., F.G.S.

Assistant in the Mineral Department of the British Museum.

Aegirine-hedenbergite. F. von Wolff, 1904. Centralblatt Min., 1904, p. 214 (Aegirin-Hedenbergit). A monoclinic pyroxene intermediate in composition between aegirite and hedenbergite. H. Rosenbusch (Mikroskopische Physiographie d. Mineralien, 4th edit., 1905, vol. i, part 2, p. 218) prefers the form Hedenbergit-Ägirin.

Analcidite. C. Hintze, 1897. Handbuch d. Mineralogie, vol. ii, p. 1714 (Analcidit). The more correct derivation of analcite, from ἄναλκις, ἀνάλκιδος, weak.

Ansilit. Zeits. Kryst. Min., 1906, vol. xli, p. 184. Error for ancylite, owing to the name having been transliterated into Russian and back again.

Antiperthite. F. E. Suess, 1905. Jahrb. geol. Reichsanst. Wien, vol. liv, pp. 419, 425 (Antiperthite, *pl.*). Regular intergrowths of two felspars in which orthoclase is the enclosed mineral and plagioclase the host; being the reverse of the case which holds in microperthite.

Argentoalgodonite. G. A. Koenig, 1903. Proc. Amer. Phil. Soc., vol. xlii, p. 229; Zeits. Kryst. Min., 1904, vol. xxxviii, p. 537. An artificially prepared copper arsenide containing some silver $(Cu,Ag)_6As$.

Argentodomeykite. G. A. Koenig, 1903. Proc. Amer. Phil. Soc., vol. xlii, p. 229; Zeits. Kryst. Min., 1904, vol. xxxviii, p. 537. An artificially prepared copper arsenide containing some silver $(Cu,Ag)_3As$.

Astrolite. R. Reinisch, 1904. Centralblatt Min., 1904, p. 108 (Astrolith). Small, greenish-yellow spheres with radially fibrous structure, which occur embedded in fragments of carbonaceous quartz-schist, limestone, and shale in a basalt-tuff at Neumark, Saxon Vogtland. $(Al,Fe)_2Fe''(Na,K)_2(SiO_3)_5 . H_2O$. Named from ἄστρον, stars, and λίθος, stone; known locally as 'Sternle'.

[1] Previous lists are given at the ends of vols. xi, xii, and xiii of this Magazine (1897, 1900, 1903).

Babylonian quartz. (P. Groth, Mineraliensammlung, Strassburg, 1878, p. 100 (Babylonquarz). Century Dictionary, New York, 1889.) Synonym of babel-quartz.

Baryta-orthoclase. J. E. Strandmark, 1904. Geol. Fören. Förh. Stockholm, 1903, vol. xxv, p. 289; 1904, vol. xxvi, p. 97. Celsian, $BaAl_2Si_2O_8$, is shown to be monoclinic and to form a series of mixed crystals with orthoclase. Celsian ranges in composition from Ce to Ce_1Or_2, the other members of the series being classed as baryta-orthoclases (baryt-kalifältspater); those having the composition Ce_1Or_2—Ce_1Or_6 are referred to hyalophane, whilst those with still less barium (Ce_1Or_6—Or) are called barium-bearing orthoclases (barythaltiga kalifältspater). J. P. Iddings (Rock Minerals, New York, 1906, p. 233) refers to minerals of the last of these divisions as barium-orthoclase.

Beckelite. J. Morozewicz, 1904. Rozpr. Akad. Kraków, Ser. A, vol. xliv, p. 216; Bull. Intern. Acad. Sci. Cracovie, 1905, année 1904, p. 485 (beckelicie, Beckelith, béckélite); Min. Petr. Mitt. (Tschermak), 1905, vol. xxiv, p. 120. Wax-yellow, octahedral or rhombic-dodecahedral crystals resembling pyrochlore in appearance and physical characters. Occurs in a dyke modification of elaeolite-syenite near Mariupol on the Sea of Azov, Russia. Calcium cero-lanthano-didymo-silicate, $Ca_3(Ce,La,Di,Y)_4(Si,Zr)_3O_{15}$. Named after Professor Friedrich Becke, of Vienna.

Bellite. W. F. Petterd, 1905. Rep. Secr. Mines, Tasmania, for 1904, p. 83. 'Chromo-arsenate of lead' occurring as velvety tufts of bright red or yellow, hexagonal needles or as powdery encrustations at Magnet, Tasmania. [The analysis suggests a mixture of crocoite, mimetite, and quartz.] Named after W. R. Bell, a prospector in Tasmania. The name bellite has long been in use for an explosive.

Beryllium-humite. H. Rosenbusch, 1905. Mikroskopische Physiographie d. Mineralien, 4th edit., vol. i, part 2, p. 193 (Berylliumhumite, *pl.*). Humite containing a small amount of beryllium (BeO, 1 per cent.) and no fluorine, $Mg_5(MgOH)_2(SiO_4)_3$. Analysed by P. Jannasch and J. Locke (1894), and described by R. W. Schäfer (1895) from the serpentine of the Allalin district, Wallis, Switzerland.

Blanfordite. L. L. Fermor, 1906. Trans. Mining and Geol. Inst. India, vol. i, p. 78. A monoclinic pyroxene containing some sodium, manganese, and iron, occurring with manganese ores in the Central Provinces, India. The strong pleochroism (rose-pink to sky-blue) is

a prominent character. Named after the late Dr. William Thomas Blanford (1832–1905).

Blomstrandine. W. C. Brögger, 1906. Videnskabs-Selsk. Skrifter, Kristiania, 1906, No. 6, p. 98 (Blomstrandin). A titano-niobate of yttrium-earths, thorium, uranium, &c., occurring at Hitterö, Arendal, and other localities in Norway, as large orthorhombic crystals, which had previously (W. C. Brögger, 1879) been referred to aeschynite. Named after the late Professor Christian Wilhelm Blomstrand (1826–97), of Lund, Sweden, whose analyses showed it to be distinct from aeschynite. It is dimorphous with polycrase and isomorphous with priorite (q.v.). Not to be confused with the blomstrandite of G. Lindström (1874), which is a hydrated titano-niobate and -tantalate of uranium, &c.

Borax, octahedral. *See* 'Octahedral borax'.

Bowmanite. R. H. Solly, 1904. Nature, vol. lxxi, p. 118; Min. Mag., 1905, vol. xiv, p. 80. Small, honey-yellow, rhombohedral crystals from the white, crystalline dolomite of the Binnenthal in Switzerland. Named after Herbert Lister Bowman, of Oxford, and proved by him (Min. Mag., 1907, vol. xiv, p. 389) to be identical with hamlinite.

Californite. G. F. Kunz, 1903. Amer. Journ. Sci., ser. 4, vol. xvi, p. 397. F. W. Clarke and G. Steiger, Bull. U.S. Geol. Survey, 1905, no. 262, p. 72. Massive, green idocrase occurring as large masses in California. It resembles jade in appearance, and is used as an ornamental stone.

Carbapatite. P. N. Tschirwinsky, 1906. Annu. Géol. Min. Russie, vol. viii, p. 251 (карбапатитъ), p. 256 (Carbapatit). A name later withdrawn (Centralblatt Min., 1907, p. 283) in favour of podolite (q.v.).

Carborundum. E. G. Acheson, 1893. Journ. Franklin Inst. Philadelphia, vol. cxxxvi, p. 194. Silicide of carbon, CSi, formed artificially as brilliant, rhombohedral crystals and extensively used as an abrasive agent. Named from carbon and corundum, because, before it had been analysed, it was thought to be a compound of carbon and alumina. More recently (1904) the same substance has been isolated from a meteoric iron and named moissanite (q.v.).

Cerepidote. H. Rosenbusch, 1905. Mikroskopische Physiographie d. Mineralien, 4th edit., vol. i, part 2, p. 286 (Cerepidot). Synonym of allanite. So named because it is a member of the epidote group containing cerium.

Chlormanganokalite. H. J. Johnston-Lavis, 1906. Nature, vol. lxxiv, p. 104. A. Lacroix, Compt. Rend. Acad. Sci. Paris, 1906, cxlii, p. 1251; H. J. Johnston-Lavis and L. J. Spencer, Nature, 1907, vol. lxxvi, p. 215. Chloride of manganese and potassium, $MnCl_2 . 4KCl$, found as yellow, deliquescent, rhombohedral crystals in blocks ejected from Mount Vesuvius.

Chlornatrokalite. H. J. Johnston-Lavis, 1906. Nature, vol. lxxiv, p. 174. Potassium and sodium chloride, 6KCl.NaCl, found as cubic crystals with chlormanganokalite in blocks ejected from Mount Vesuvius.

[Specimens of 'chlornatrokalite' sent by Dr. Johnston-Lavis to the British Museum consist of cubes of sylvite and of halite in association.—L. J. S.]

Chocolite. J. Garland, 1894. Trans. Inst. Mining and Metallurgy, 1893–4, vol. ii, pp. 128, 224. A chocolate-coloured nickel-ore from New Caledonia; a hydrated silicate of iron, nickel, and magnesium, related to garnierite.

Coronadite. W. Lindgren and W. F. Hillebrand, 1904. Amer. Journ. Sci., ser. 4, vol. xviii, p. 448; Bull. U.S. Geol. Survey, 1905, no. 262, p. 42; Profess. Paper U.S. Geol. Survey, 1905, no. 43, p. 103. A black, metallic mineral with finely fibrous structure; not unlike psilomelane in appearance. Manganite of lead and manganese, $(Pb,Mn)O . 3MnO_2$. Occurs in fairly large amount in the Coronado vein, Clifton-Morenci district, Arizona. Named after the Spanish explorer, Francisco Vasquez de Coronado, who visited the region in 1540.

Crenite. D. A. Wells, 1852. Proc. Amer. Assoc. Adv. Sci., vol. vi, p. 230. Stalactitic calcite coloured yellow by organic matter, which was identified with crenic acid or crenate of calcium.

[J. Fromme (Jahresber. Ver. Naturwiss. Braunschweig, 1897, vol. x, p. 104) found 0·231 per cent. of apocrenic acid in chestnut-brown, translucent crystals of calcite from the Harz.]

Cryolithionite. N. V. Ussing, 1904. Overs. K. Danske Videnskab. Selsk. Forhandl., 1904, p. 3. Large, colourless rhombic-dodecahedra found in the cryolite of Greenland. $Li_3Na_3Al_2F_{12}$. So named because of its relation to cryolite and the large amount of lithium (5·35 per cent.) it contains.

Dachiardite. G. D'Achiardi, 1906. *See* Zeolite mimetica.

Davidite. D. Mawson, 1906. Trans. R. Soc. South Australia, vol. xxx, p. 191. An incompletely described mineral [possibly identical

with ilmenite] from South Australia. Named after Professor T. W. Edgeworth David, of Sydney University.

Denhardtite. H. Potonié, 1905. Monatsber. Deutsch. geol. Ges., 1905, p. 259 (Denhardtit). A pale yellow, waxy hydrocarbon similar to pyropissite. It is derived from plants and forms a stratum in loam in British East Africa. Named after the brothers Clemens and Gustav Denhardt, by whom it was collected in 1878.

Doughtyite. W. P. Headden, 1905. Proc. Colorado Sci. Soc.,vol. viii, p. 66. Hydrated basic aluminium sulphate, $Al_2(SO_4)_3 . 5Al_2(OH)_6 . 21H_2O$, formed abundantly as a white precipitate by the interaction of the waters (an alkaline water and one containing aluminium sulphate) of the Doughty Springs, in Delta Co., Colorado. Named after Mr. Doughty, the owner of the springs.

Dubuissonite. C. Baret, 1904. Bull. Soc. Sci. Nat. de l'ouest de la France, Nantes, ser. 2, vol. iv, p. 141. A pink clay from near Nantes, analysed by A. Damour in 1885 and placed by A. Lacroix (Minéralogie de la France, 1895, vol. i, p. 483) under montmorillonite; it differs from this, however, in its resistance to acids and in its fusibility. Named after Mr. Dubuisson, mineralogist and founder of the museum at Nantes.

Ebelmenite. (Collection de Minéralogie du Muséum d'Histoire Naturelle, Paris, Guide du Visiteur, 2nd edit., 1900, p. 29.) A variety of psilomelane containing potassium. Named after Jacques Joseph Ebelmen (1814–52), who analysed a specimen in 1841.

Erikite. O. B. Boeggild, 1903. Contributions to Mineralogy, Min. Geol. Mus. Univ. Copenhagen, no. 2, p. 93; Meddelelser om Grønland, 1904, vol. xxvi, p. 93. Brown and opaque, orthorhombic crystals from the nephelite-syenite near Julianehaab in Greenland, when examined in thin section under the microscope, were seen to consist of an intergrowth of two substances, of which the predominant one (erikite) is yellow, strongly refracting and birefringent, whilst the other is probably hydronephelite. An analysis of this mixture corresponds with the formula $8SiO_2 . 4P_2O_5 . 4(Ce,La,Di)_2O_3 . 3Al_2O_3 . CaO . 3Na_2O . 11H_2O$. Named after Erik the Red, who discovered Greenland in A.D. 986.

Ferrinatrite. R. Scharizer, 1905. Zeits. Kryst. Min., vol. xli, p. 209 (Ferrinatrit). To replace the name ferronatrite (J. B. Mackintosh, 1889), since the mineral to which it is applied is a hydrated sodium ferric (not ferrous) sulphate.

Giorgiosite. A. Lacroix, 1905. Compt. Rend. Acad. Sci. Paris,

vol. cxl, p. 1310; Bull. Soc. franç. Min., vol. xxviii, p. 198. A basic magnesium carbonate occurring as a white powder on lava erupted from Santorin in 1866. Under the microscope it is seen to consist of minute, birefringent spherules, and to have the same characters as the artificial compound $4MgCO_3 . Mg(OH)_2 . 4H_2O$. Named from Giorgios, one of the cones formed during the eruption of 1866.

Glendonite. T. W. E. David and T. G. Taylor, 1905. Records Geol. Survey New South Wales, vol. viii, p. 161. Large pseudomorphs of granular calcite, probably after glauberite, found in abundance at Glendon on the Hunter River and other localities in New South Wales. They were described by J. D. Dana in 1849, and are similar to thinolite and pseudogaylussite.

Gorceixite. E. Hussak, 1906. Min. Petr. Mitt. (Tschermak), vol. xxv, p. 338 (Gorceixit). Hydrated barium aluminium phosphate, $BaO . 2Al_2O_3 . P_2O_5 . 5H_2O$, occurring as brown pebbles ('favas'), with a compact, jaspery structure, in the diamond-bearing sands of Brazil. It is optically uniaxial, and belongs to the hamlinite group of minerals. Named after Professor Henri Gorceix, formerly director of the School of Mines at Ouro Preto, Brazil.

Greenalite. C. K. Leith, 1903. Monogr. U.S. Geol. Survey, vol. xliii, pp. 14, 101, 239. A hydrous silicate of iron occurring in the form of green granules and closely resembling glauconite, from which it differs in containing no potassium. The composition varies somewhat; one analysis gives the formula $Fe_2'''(Fe,Mg)_3(SiO_4)_3 . 3H_2O$. Occurs abundantly as a constituent of sedimentary rocks in the Mesabi iron-bearing district of Minnesota.

Greenite. John Ruskin, 1884. Catalogue of a series of specimens in the British Museum (Natural History) illustrative of the more common forms of native silica. Orpington, Kent (G. Allen), 1884, p. 28. The English equivalent of chlorite. 'Chlorite, which ought to be more simply termed "Greenite" or "Greeny", is a combination of . . .'

Harttite. E. Hussak, 1906. Min. Petr. Mitt. (Tschermak), vol. xxv, p. 341 (Harttit). Hydrated strontium aluminium sulphato-phosphate, $SrO . 2Al_2O_3 . P_2O_5 . SO_3 . 5H_2O$, near svanbergite in composition. It is found as flesh-red pebbles ('favas') in the diamond-bearing sands of Brazil. The crystalline structure is rhombohedral. Named in memory of Charles Frederick Hartt (1840–78), the first director of the Geological Survey of Brazil.

Hedenbergit-Ägirin. *See* Aegirine-hedenbergite.

Hibschite. F. Cornu, 1905. Min. Petr. Mitt. (Tschermak), vol. xxiv, p. 327; 1906, vol. xxv, p. 249 (Hibschit). Minute, octahedral, optically isotropic crystals of contact-metamorphic origin, occurring in enclosures of chalk-marl in phonolite at Aussig, Bohemia. It usually forms a colourless layer around a nucleus of green titaniferous melanite. The chemical composition, $H_4CaAl_2Si_2O_{10}$, is the same as of the orthorhombic lawsonite. Named after Professor Josef Emanuel Hibsch, of Tetschen, Bohemia.

The same mineral also occurs in enclosures of limestone in basalt at Aubenas, Ardèche, France, and was described by A. Lacroix in 1893 as colourless garnet with a core of brown melanite.

Hollandite. L. L. Fermor, 1906. Trans. Mining and Geol. Inst. India, vol. i, p. 76. A crystallized manganate of barium, manganese, and ferric iron, $m(Ba,Mn)_2MnO_5 + nFe_4(MnO_5)_3$. From Central India. Named after Thomas Henry Holland, Director of the Geological Survey of India.

Hutchinsonite. R. H. Solly, 1904. Min. Mag., 1905, vol. xiv, p. 72. (A preliminary account of the unnamed mineral appeared in Nature, 1903, vol. lxix, p. 142, and the name (Hutchinsonit) was first printed in Min. Petr. Mitt. (Tschermak), 1904, vol. xxiii, p. 551.) G. T. Prior, Nature, 1905, vol. lxxi, p. 534. G. F. H. Smith and G. T. Prior, Min. Mag., 1907, vol. xiv, p. 284. Minute, red, orthorhombic crystals found in the white, crystalline dolomite of the Binnenthal, Switzerland. An analysis made on a small amount of material suggests the formula $(Tl,Cu,Ag)_2S \cdot As_2S_3 + PbS \cdot As_2S_3$; thallium is present to the extent of about 20 per cent. Named after Dr. Arthur Hutchinson, of Cambridge.

Ilmenitglimmer. H. Rosenbusch, 1905. Mikroskopische Physiographie d. Mineralien, 4th edit., vol. i, part 2, p. 81. The same as Titaneisenglimmer (q.v.).

Irvingite. S. Weidman, 1907. Amer. Journ. Sci., ser. 4, vol. xxiii, p. 451. A variety of lithia-mica differing somewhat from other varieties in chemical composition. Occurs with marignacite (q. v.) in pegmatite-veins near Wausau, Wisconsin. Named after Roland Duer Irving (1847–88), formerly of the Geological Survey of Wisconsin.

Isorthose. L. Duparc, 1904. Compt. Rend. Acad. Sci. Paris vol. cxxxviii, p. 715. A variety of orthoclase (French, orthose) differing from ordinary orthoclase in optical orientation: the acute bisectrix of the optic axes is positive in sign and is perpendicular to the plane

of symmetry. It is met with in granite from the northern Urals and in the protogine of Mont Blanc.

Janosite. H. Böckh and K. Emszt, 1905, Földtani Közlöny, Budapest, vol. xxxv, pp. 76, 139; ibid., vol. xxxvi, pp. 186, 228, 404, 455 (Jánosit). Described as an orthorhombic, hydrated normal ferric sulphate, $Fe_2O_3.3SO_3,9H_2O$, dimorphous with coquimbite; it occurs as a greenish-yellow, powdery efflorescence at Vashegy, Comitat Gömör, Hungary. Named after Dr. János [=John] Böckh, Director of the Geological Survey of Hungary.

Proved by E. Weinschenk (ibid., 1906, vol. xxxvi, pp. 182, 224, 289, 359) and Z. Toborffy (ibid., 1907, vol. xxxvii, pp. 122, 173; Zeits. Kryst. Min., 1907, vol. xliii, p. 369) to be identical with copiapite, $2Fe_2O_3 . 5SO_3 . 18H_2O$, which is orthorhombic and not monoclinic.

Jentschite. Min. Petr. Mitt. (Tschermak), 1904, vol. xxiii, p. 551; Min. Mag., 1905, vol. xiv, p. 80 footnote. Synonym of lengenbachite (q.v.). Named after Franz Jentsch, mineral dealer of Binn, Switzerland. Not to be confused with the jenzschite of J. D. Dana, 1868.

Johnsonite. H. D. Richmond and H. Off, 1892. Chemiker-Zeitung, Jahrg. xvi, pp. 567, 648 (Johnsonit); Chem. News, vol. lxv, p. 257. A fibrous alum, containing the supposed new element masrium, found in Egypt by S. E. Johnson Pasha. The mineral was immediately afterwards re-named masrite (see first list, Min. Mag., vol. xi, p. 331).

Justite. Min. Petr. Mitt. (Tschermak), 1904, vol. xxiii, p. 97 (Justit); the name also appears on dealers' labels. Synonym of koenenite (see third list, Min. Mag., vol. xiii, p. 369). Named from the Justus I salt-mine in Hanover, where the mineral was found.

Kassiterolamprit. A. Frenzel. C. Hintze, Handbuch d. Mineralogie, 1904, vol. i, p. 1191 footnote. Thought to be a new mineral from Bolivia, but afterwards identified with stannite.

Katharite. W. Ainsworth, 1834. An account of the caves of Ballybunian, County of Kerry: with some mineralogical details. Dublin, 1834, pp. 83, 85. Synonym of alunogen. Named katherite or katharite from καθαρος [i. e. κάθαρός], impermixtus, simplex; in allusion to the absence of potash', it being hydrous aluminium sulphate and thus more simple in composition than alum.

Kertschenite. S. P. Popoff, 1906. Centralblatt Min., 1906, p. 113 (Kertschenit). Hydrated phosphate of iron with small amounts of manganese and magnesium, $(Fe,Mn,Mg)O . Fe_2O_3 . P_2O_5 . 7H_2O$. It occurs

as radially fibrous aggregates of dark-green, flattened crystals in the limonitic iron-ores of the Kerch (German, Kertsch) peninsula, Crimea.

Kleinite. A. Sachs, 1905. Sitzungsber. Akad. Wiss. Berlin, 1905, p. 1091; Centralblatt Min., 1906, p. 200 (Kleinit). An oxychloride of mercury, $Hg_4Cl_2O_3$, containing small amounts of nitrogen and sulphate. It occurs as sulphur-yellow, hexagonal crystals in the mercury-mines at Terlingua, Texas. Named after Professor Carl Klein (1842–1907), of Berlin.

Kutnohorite. A. Bukovský, 1901. [Anz. III Congr. böhm. Naturf. u. Aerzte, Prag, 1901, p. 293; Programm d. Oberrealschule in Kuttenberg, 1902]; Neues Jahrb. Min., 1903, vol. ii, Ref. p. –338– (Kutnohorit). A rhombohedral carbonate with the atomic ratios Ca : Mn : Fe : Mg = 7 : 5 : 1 : 2, occurring as reddish-white cleavage-masses at Kutná Hora (German, Kuttenberg), Bohemia.

Landerite. M. M. Villada, 1891. La Naturaleza, México, ser. 2, vol. i, p. 502 (Landerita). A beautiful, pink grossularite occurring as large rhombic-dodecahedra embedded in white marble at Xalostoc, Morelos, Mexico. It was analysed by A. Damour in 1871 and by Carlos F. de Landero in 1891, after whom it is named. Also called rosolite and xalostocite (q.v.).

Landevanite. Comte de Limur. A. Lacroix, Minéralogie de la France, 1895, vol. i, p. 484. 'Under the name of landevanite, M. de Limur has distributed to his correspondents a rose-coloured clay coming from Landevan in Morbihan and resulting from the decomposition of a pegmatite rich in albite.' It is placed by Lacroix under montmorillonite.

Lengenbachite. R. H. Solly, 1904. Nature, vol. lxxi, p. 118; Min. Mag., 1905, vol. xiv, p. 78. Thin, blade-shaped crystals, probably anorthic, occurring in the white, crystalline dolomite of the Lengenbach, Binnenthal, Switzerland. Analysis by A. Hutchinson (Min. Mag., 1907, vol. xiv, p. 204) gives the formula $Pb_6(Ag,Cu)_2As_4S_{13}$. *See* Jentschite.

Lepidolamprite or Schuppenglanz. A. Breithaupt. C. Hintze, Handbuch d. Mineralogie, 1904, vol. i, p. 1198 footnote (Lepidolamprit). A specimen of franckeite (A. W. Stelzner, 1893) in the Freiberg collection was so labelled by Breithaupt in the first half of the nineteenth century.

Magnesium-diopside. H. Rosenbusch, 1905. Mikroskopische Physiographie d. Mineralien, 4th edit., vol. i, part 2, pp. 200, 206 (Magnesiumdiopsid). A monoclinic pyroxene near to diopside, but containing only 8–9 per cent. CaO.

Marignacite. S. Weidman and V. Lenher, 1907. Amer. Journ. Sci., ser. 4, vol. xxiii, p. 287. A variety of pyrochlore occurring as brown octahedra in pegmatite at Wausau, Wisconsin. It differs from other members of the pyrochlore group in containing rather more cerium and yttrium with less calcium and iron, and in the presence of a small amount of silica. Named after Jean Charles Galissard de Marignac ((1817–94).

Marrite. R. H. Solly, 1904. Nature, vol. lxxi, p. 118; Min. Mag., 1905–6, vol. xiv, pp. 76, 188. Small, steel-grey crystals with brilliant metallic lustre found in the white, crystalline dolomite of the Binnenthal, Switzerland. They are monoclinic with a rich development of faces; their chemical composition is not known. Named after Dr. John Edward Marr, of Cambridge.

Metaautunite. P. Gaubert, 1904. Bull. Soc. franç. Min., xxvii, p. 224 (Métaautunite). The same as Metakalkuranit (F. Rinne, 1901; third list, Min. Mag., xiii, p. 371).

Metaboracite. E. S. Fedorov, 1892. Zeits. Kryst. Min., vol. xx, p. 74. The names metaboracite, metaleucite, and metaperovskite (Metaboracit, Metaleucit, Metaperowskit) are applied to those dimorphous forms possessing higher symmetry met with at ordinary temperatures, whilst the names boracite, leucite, and perovskite respectively, are restricted to the cubic, optically isotropic modifications of the same substances which are stable only above certain temperatures.

Metachalcophyllite. P. Gaubert, 1904. Bull. Soc. franç. Min., vol. xxvii, p. 224 (Métachalcophyllite). Following F. Rinne (1901), this name is given to chalcophyllite which has been partly dehydrated by heating artificially until only the water of constitution remains; the loss of water is accompanied by changes in the optical characters.

Metaleucite. E. S. Fedorov, 1892. *See* Metaboracite.

Metanhydrite. E. Sommerfeldt, 1907. Neues Jahrb. Min., vol. i, p. 140 (Metanhydrit). A modification of calcium sulphate which in external form appears to be isomorphous with barytes, though in physical characters (sp. gr. and cleavage) it is identical with anhydrite. The crystals examined were prepared artificially: the same substance probably occurs as a volcanic product at Santorin.

Metaperovskite. E. S. Fedorov, 1892. *See* Metaboracite.

Metauranocircite. P. Gaubert, 1904. Bull. Soc. franç. Min., vol. xxvii, p. 226 (Métauranocircite). *See* Metachalcophyllite.

Micaultlite. Comte de Limur, 1883. Catalogue raisonné des minéraux du Morbihan. Vannes, 1883, p. 38. An earthy, brick-red decomposition product of rutile, which is suggested may be an aluminous hydrorutile. Presumably named after Victor Micault, of Paris.

Minette. A mining term applied to oolitic brown-iron-ores (limonite) of Lorraine and Luxemburg. A diminutive of the French *mine*, ore, in allusion to the low content of metal in the ore.

Moissanite. G. F. Kunz, 1905. Centralblatt Min., 1905, p. 154; Amer. Journ. Sci., ser. 4, vol. xix, p. 396. Silicide of carbon, CSi, identical with the artificial product known as carborundum (q. v.), found by H. Moissan (Compt. Rend. Acad. Sci. Paris, 1904, vol. cxxxix, p. 778; 1905, vol. cxl, p. 405) as small, green, hexagonal plates in the meteoric iron of Cañon Diablo, Arizona. Named after Professor Henri Moissan (1852–1907).

Moravite. F. Kretschmer, 1906. Centralblatt Min., 1906, p. 293 (Moravit). A finely scaly chloritic mineral, of the leptochlorite group, occurring abundantly as iron-black masses with sub-metallic lustre in association with iron-ores at Gobitschau in Moravia. It resembles thuringite in appearance, but differs chemically from this, the formula being $H_4(Al,Fe)_4(Fe,Mg)_2Si_7O_{24}$. Named from the locality.

Morencite. W. Lindgren and W. F. Hillebrand, 1904. Amer. Journ. Sci., ser. 4, vol. xviii, p. 455; Bull. U.S. Geol. Survey, 1905, no. 262, p. 49; Profess. Paper U.S. Geol. Survey, 1905, no. 43, p. 115. A brownish-yellow mineral occurring in finely fibrous seams, the minute fibres having straight extinction. Hydrated ferric silicate with some magnesia, lime, &c., and a little alumina; $H_{22}R_2''Fe_6'''(SiO_4)_{11}$. Occurs in calcareous shale at Morenci, Arizona, and is probably an alteration product of some contact-metamorphic mineral.

Naegite. T. Wada, 1904. Minerals of Japan. Tōkyō, p. 49 (Naëgite). A tetragonal mineral occurring as small, rather indistinct crystals with angles near those of zircon. Described as a silicate of uranium, thorium, &c., and considered to be isomorphous with zircon; in a later analysis (Beiträge zur Mineralogie von Japan, 1906, no. 2, p. 23) zirconium figures largely. [Further investigation will probably prove its identity with zircon.] Found in alluvial tin-washings at Naëgi, near Takayama, Prov. Mino, Japan.

Nemaphyllite. F. Focke, 1902. Min. Petr. Mitt. (Tschermak), vol. xxi, p. 323 (Nemaphyllit). A chlorite-like mineral occurring as

greenish scales with a fibrous structure: it has the composition of serpentine ($H_4Mg_3Si_2O_9$), containing also 2·11 per. cent. Na_2O. It is from the Zillerthal, Tyrol, where it sometimes forms regular intergrowths with dolomite. Named from *νῆμα*, a thread, and *φύλλον*, a leaf.

Nepouite. E. Glasser, 1906. Compt. Rend. Acad. Sci. Paris, vol. cxliii, p. 1173; Bull. Soc. franç. Min., 1907, vol. xxx, p. 17 (Népouite). A hydrated silicate of nickel (NiO,18·1—50·7 per cent.) and magnesium (MgO,3·0—30·0 per cent.) with the formula $3(Ni,Mg)O \cdot 2SiO_2 \cdot 2H_2O$, occurring as a finely crystalline, bright green to pale yellowish-green powder in niccoliferous peridotite at Népoui in New Caledonia. It differs from connarite, garnierite, &c., and in its optical characters it resembles the chlorites.

N'hangellite. (L. A. Boodle, Bull. Roy. Botanic Gardens, Kew, 1907, p. 145; Sir Boverton Redwood, ibid., p. 151.) An elastic bitumen derived from a gelatinous alga, and resembling coorongite; from the neighbourhood of Lake N'hangella in Portuguese East Africa.

Nuissierite. The same as nussierite (G. Barruel, 1836). A calciferous mimetite from the Nuissière lead-mine near Chenelette, dep. Rhône, France. The new spelling (nuissiérite) is given by A. Des Cloizeaux, Manuel de Minéralogie, 1893, vol. ii, p. 519.

'Octahedral borax.' The conditions necessary for the formation of the artificial salt long known as 'octahedral borax' (sodium borate, $Na_2B_4O_7 \cdot 5H_2O$, crystallizing in rhombohedral forms $r\,c$ with the appearance of regular octahedra) have been investigated by J. H. van 't Hoff and W. C. Blasdale (Sitzungsber. Akad. Wiss. Berlin, 1905, p. 1086), who point out that this substance was observed by E. Bechi in 1854 as an incrustation at the Tuscan lagoons.

Oehrnite. E. S. Fedorov, 1905. Gornyi Zhurnal, St. Petersburg, year lxxxi, vol. iii, p. 264 (эрнитъ, Oehrnit). A rock-forming mineral from the Caucasus resembling diallage in appearance: it has three rectangular cleavages, but is shown by its optical characters to be monoclinic. The formula is given as $6(Mg,Fe,Ca)O \cdot 6SiO_2 \cdot H_2O$, but the analysis shows also Al_2O_3, 6·74 per cent. Named after A. G. Ern, a Russian mining engineer.

Osannite. C. Hlawatsch, 1906. Festschrift Harry Rosenbusch, Stuttgart, 1906, p. 76 (Osannit). Those soda-amphiboles, intermediate between riebeckite and arfvedsonite, in which the optic axial plane is perpendicular to the plane of symmetry and the acute, negative bisectrix

nearly coincides with the vertical prism-axis. A constituent of amphibole-gneiss at Cevadaes, Portugal. Named after Professor Alfred Osann, of Freiberg in Baden.

Otavite. O. Schneider, 1906. Centralblatt Min., 1906, p. 389 (Otavit). A basic carbonate of cadmium (Cd, 61·5 per cent.) occurring as minute, curved rhombohedra and forming white to reddish crystalline crusts on copper-ores at Otavi in German South-West Africa.

Palaeoleucite. H. Rosenbusch, 1905. Mikroskopische Physiographie d. Mineralien, 4th edit., vol. i, part 2, p. 33 (Paläoleucit). The original mineral of pseudoleucite. *See* Soda-leucite.

Palmerite. E. Casoria, 1904. Atti R. Accad. Georgofili, Firenze, ser. 5, vol. i, p. 293; Ann. R. Scuola Sup. Agric. Portici, 1904, vol. vi. Hydrated aluminium potassium phosphate, $HK_2Al_2(PO_4)_3 . 7H_2O$, occurring as a white powder under bat-guano in a cave on Monte Alburno, Salerno, Italy. Named after Paride Palmeri, professor of chemistry in the Royal School of Agriculture at Portici, near Naples.

Palmierite. A. Lacroix, 1907. Compt. Rend. Acad. Sci. Paris, vol. cxliv, p. 1400 (palmiérite). Minute hexagonal scales which are optically uniaxial with strong negative birefringence; found enclosed in aphthitalite amongst the products of the Vesuvian eruption of April, 1906. Anhydrous sulphate of lead, potassium, and sodium, $PbSO_4 . (K,Na)_2SO_4$. Named after Luigi Palmieri (1807–96).

Paracelsian. E. Tacconi, 1905. Rend. R. Istit. Lombardo, ser. 2, vol. xxxviii, p. 642 (Paracelsiana). A mineral with the composition $Ba_3Al_8Si_8O_{31}$, occurring as pale yellow granules in veins in crystalline schists at Candoglia, Piedmont. It is near to celsian ($BaAl_2Si_2O_8$) in composition and optical characters, but it seems to differ from this in possessing only poor cleavage.

Paratacamite. G. F. H. Smith, 1905. Nature, vol. lxxi, p. 574; Min. Mag., 1906, vol. xiv, p. 170; Zeits. Kryst. Min., 1907, vol. xliii, p. 28. Hydrated oxychloride of copper, $Cu_2Cl(OH)_3$, dimorphous with atacamite. The bright green crystals are rhombohedral but with optical anomalies. From Chili.

Paravivianite. S. P. Popoff, 1906. Centralblatt Min., 1906, p. 112. A variety of vivianite with part of the iron replaced by small amounts of manganese and magnesium, $(Fe,Mn,Mg)_3P_2O_8 . 8H_2O$. Occurs as blue, acicular crystals in limonitic iron-ore in South Russia.

Patronite. F. Hewett. Engineering and Mining Journ. New York, 1906, vol. lxxxii, p. 385. C. Matignon, Revue Scientifique, Paris, 1906, ser. 5, vol. vi, p. 597. A dark green mineral containing much vanadium, perhaps vanadium sulphide, but not yet completely determined. It occurs with vanadiferous asphaltum near Cerro de Pasco in Peru. Named after Antenor Rizo Patrón, of the Huaraucaca smelting works near Cerro de Pasco, who detected the vanadium.

Pearcit. P. Groth, Tabell. Uebersicht d. Mineralien, 4th edit., 1898, p. 38. Error for pearceite: named after Dr. Richard Pearce.

Pholidite. C. Hintze, 1892. Handbuch d. Mineralogie, vol. ii, p. 835 footnote (Pholidit). The more correct derivation of pholerite, from *φολίς, φολίδος*, a scale; a scaly variety of kaolinite.

Phosphorus. Evidence of the existence of native phosphorus in a meteoric stone is adduced by O. C. Farrington, Amer. Journ. Sci., 1903, ser. 4, vol. xv, p. 71; Chem. News, 1903, vol. lxxxvii, p. 66.

Picrocrichtonite. (Collection de Minéralogie du Muséum d'Histoire Naturelle, Paris, Guide du Visiteur, 2nd edit., 1900, p. 24.) A. Lacroix, Minéralogie de la France, 1901, vol. iii, p. 284. Synonym of picroilmenite $(Fe,Mg)TiO_3$ (compare Min. Mag., vol. xiv, p. 165). Lacroix distinguishes between crichtonite ($FeTiO_3$) and ilmenite ($FeTiO_3 . xFe_2O_3$); hence the above name for the magnesian variety.

Podolite. W. Tschirwinsky, 1907. Centralblatt Min., 1907, p. 279 (Podolit). A mineral closely related to apatite and staffelite, but with the composition $3Ca_3(PO_4)_2 . CaCO_3$, occurring as minute hexagonal crystals in phosphorite nodules in govt. Podolia, South Russia. It had earlier been called carbapatite (q. v.).

Prasiolite. C. Hintze, Handbuch d. Mineralogie, 1892, vol. ii, p. 940 (Prasiolith). Variant of praseolite (Praseolit, A. Erdmann, 1842). Hintze gives as derivation *πράσιος*, leek-green, and *λίθος*, stone; whilst Erdmann gives *πράσον*, leek, and *λίθος*.

Priorite. W. C. Brögger, 1906. Videnskabs-Selsk. Skrifter, Kristiania, 1906, no. 6, p. 110 (Priorit). A titano-niobate of yttrium, cerium-earths, &c., found as indistinct orthorhombic crystals in the tin gravels of Swaziland, South Africa. Named after Dr. George Sherland Prior, of the British Museum, who analysed it (Min. Mag., 1909, vol. xii, p. 96). It is isomorphous with blomstrandine (q.v.) and isomorphous with euxenite, the four minerals euxenite-polycrase and priorite-blomstrandine forming an isodimorphous group.

Pseudo-jade. A name which may be applied to any mineral resembling jade in appearance; for example, bowenite (C. A. McMahon, Min. Mag., 1890, vol. ix, p. 187).

Pseudomeionite. H. Rosenbusch, 1902. Mitt. Grossherz. Badisch. geol. Landesanst., vol. iv, p. 391 (Pseudomejonit). A name provisionally given to a felspathoid mineral occurring with bytownite in a para-amphibole-gneiss from the Black Forest; it has the microscopical characters of meionite, except in possessing a good basal cleavage.

Pseudowollastonite. E. T. Allen and W. P. White, 1906. Amer. Journ. Sci., ser. 4, vol. xxi, p. 89 (Pseudo-Wollastonite). An artificial product usually known as hexagonal calcium metasilicate: the crystals are, however, pseudo-hexagonal and probably monoclinic. Wollastonite when heated to 1180° C. becomes changed, without melting, into this dimorphous modification.

Purpurite. L. C. Graton and W. T. Schaller, 1905. Amer. Journ. Sci., ser. 4, vol. xx, p. 146; Zeits. Kryst. Min., 1906, vol. xli, p. 433. A hydrous manganic ferric phosphate, $2(Mn,Fe)PO_4 . H_2O$, with a purple or dark reddish colour; hence the name, from the Latin, purpura, purple. It is probably orthorhombic, and occurs in small irregular masses as an alteration product of lithiophilite and triphylite in the lithium-bearing pegmatite-veins of North Carolina and of San Diego Co., California.

Radiobaryt. J. Knett, 1904. Sitzungsber. Akad. Wiss. Wien, vol. cxiii, Abt. IIa, p. 761. Crystals of barytes from the hot springs of Carlsbad, Bohemia, but not crystals from other localities, were found to be radio-active (as demonstrated by their action on a photographic plate).

Radiotine. R. Brauns, 1904. Neues Jahrb. Min., Beil.-Bd. xviii, p. 314 (Radiotin). Small spheres with radially fibrous structure occurring in a serpentine which has resulted from the alteration of picrite near Dillenburg, Nassau. It has the same composition as serpentine ($H_4Mg_3Si_2O_9$), but differs from this in not being attacked by hydrochloric acid and in its higher specific gravity of 2·70. So named because of its radial structure and its relation to serpentine.

Rancieite. (Collection de Minéralogie du Muséum d'Histoire Naturelle, Paris, Guide du Visiteur, 2nd edit., 1900, p. 29 (Ranciéite).) The correct spelling of rancierite (A. Leymerie, 1857), a variety of wad (hydrated manganese oxide) from the iron-mines of Rancié, Ariège, France.

Reyerite. F. Cornu, 1906. Min. Petr. Mitt. (Tschermak), 1906–7, vol. xxv, pp. 211, 519 (Reyerit). A 'micaceous zeolite' indistinguishable in appearance from gyrolite and zeophyllite. The thin plates with perfect cleavage and pearly lustre are rhombohedral and form radial aggregates. Sp. gr. 2·499—2·578; refractive index (ω) 1·564. Hydrous silicate of calcium with a little aluminium. The specimens examined were collected in Greenland by C. L. Giesecke in 1807–13, and the mineral is probably identical with his 'Glimmerzeolith' (see Min. Mag., vol. xiv, p. 95). Named after Professor Eduard Reyer, of Vienna.

Romanechite. (Collection de Minéralogie du Muséum d'Histoire Naturelle, Paris, Guide du Visiteur, 2nd edit., 1900, p. 29 (Romanéchite).) Psilomelane from Romanèche, France, with the composition $(Ba,Mn)O.3MnO_2 . H_2O$; analysed by A. Gorgeu (1890).

Rosolite. (Trans. Amer. Inst. Mining Engin., 1902, vol. xxxii, pp. 55, 57.) A rose-pink garnet from Mexico. *See* Landerite.

Rutherfordine. W. Marckwald, 1906. Centralblatt Min., 1906, p. 763 (Rutherfordin). A yellow uranyl carbonate, $UO_2 . CO_3$, resembling uranochre in appearance and resulting by the alteration of uraninite; from German East Africa. It is strongly radio-active, and is named after a prominent worker in radio-activity, Professor Ernest Rutherford, of Manchester, formerly of the McGill University, Montreal. Not to be confused with rutherfordite (C. U. Shepard, 1851) from Rutherford Co., North Carolina.

Schertelite. Zeits. Kryst. Min., 1906, vol. xlii, p. 386 (Schertelit). The correct spelling of schertalite (R. W. E. MacIvor, 1902; third list, Min. Mag., vol. xiii, p. 376). Named after Arnulf Schertel (1841–1902), formerly professor in the Bergakademie of Freiberg, Saxony.

Schuppenglanz. *See* Lepidolamprite.

Silicomagnesiofluorite. P. A. Zemlatčenskij, 1906. Zeits. Kryst. Min., vol. xlii, p. 209 (Silicomagnesiofluorit). Ash-grey, greenish, or bluish, radially-fibrous aggregates associated with quartz and serpentine, in a boulder at Luppiko, Finland. The fibres are optically positive and give straight extinction. Formula, $H_2Ca_4Mg_3Si_2O_7F_{10}$. So named on account of its composition.

Smithite. R. H. Solly, 1905. Min. Mag., vol. xiv, p. 74. (A preliminary description of the unnamed mineral appeared in Nature, 1903, vol. lxix, p. 142.) G. F. H. Smith and G. T. Prior, Min. Mag., 1907, vol. xiv, p. 293. Minute, red, monoclinic crystals found in the white,

crystalline dolomite of the Binnenthal, Switzerland. Sulpharsenite of silver, $AgAsS_2$. Named after Dr. George Frederick Herbert Smith, of the British Museum.

Soda-leucite. An analysis of pseudoleucite, consisting of a mixture of orthoclase, nephelite, scapolite, &c., showed the presence of 7·08 per cent. Na_2O with 8·49 per cent. K_2O; this suggests that the original mineral was a soda-leucite (C. W. Knight, Amer. Journ. Sci., 1906, ser. 4, vol. xxi, p. 292). A soda-leucite (Natronleucit) was prepared artificially by J. Lemberg in 1876. *See* Palaeoleucite.

Sommairite. (British Museum (Natural History), Students' Index to the Collection of Minerals, 1897. Collection de Minéralogie du Muséum d'Histoire Naturelle, Paris, Guide du Visiteur, 2nd edit., 1900, p. 32.) Zinciferous melanterite from Laurion, Greece; analysed, but not named sommairite, by L. Michel (Bull. Soc. franç. Min., 1893, vol. xvi, p. 204).

Soretite. L. Duparc and F. Pearce, 1903. Arch. Sci. Phys. Nat. Genève, ser. 4, vol. xvi, p. 599 (Soretite); Bull. Soc. franç. Min., vol. xxvi, p. 126 (sorétite). A variety of common aluminous hornblende, defined by its optical characters, which vary, however, in different specimens. It occurs in anorthite-diorite at Koswinsky Kamen, northern Urals. Named after the late Professor Charles Soret (1854–1904), of Geneva.

Souesite. G. C. Hoffmann, 1905. Amer. Journ. Sci., ser. 4, vol. xix, p. 319. A native nickel-iron alloy occurring as small, rounded grains in the auriferous gravels of the Fraser River, British Columbia. Named after F. Soues, who sent the material for identification.

G. S. Jamieson (Amer. Journ. Sci., 1905, ser. 4, vol. xix, p. 413; Zeits. Kryst. Min., 1905, vol. xli, p. 157) points out that awaruite, josephinite, souesite, and other terrestrial nickel-iron alloys have no definite composition, though they all lie between $FeNi_3$ and $FeNi_2$; and he proposes that they should all be referred to the earliest name awaruite (W. Skey, 1885).

Spandite. L. L. Fermor, 1907. Records Geol. Survey India, vol. xxxv, p. 22. The term spessart-andradite, contracted to spandite, is applied to garnets intermediate in chemical composition between spessartite and andradite.

Stilpnochlorane. F. Kretschmer. 1905. Centralblatt Min., 1905, p. 203; 1907, p. 292 (Stilpnochloran). A chloritic mineral occurring

as shining, yellow scales in the iron-mines at Gobitschau, Moravia. It is an alteration product of thuringite, and has the composition $H_{24}(Al,Fe)_{10}(Ca,Mg)Si_9O_{46}$. Named from στιλπνός, glistening, and χλωρός, pale-green, yellow.

Strüverite. F. Zambonini, 1907. Rend. Accad. Sci. Napoli, ser. 3, vol. xiii, p. 35. A black, tetragonal mineral, with angles near those of rutile and tapiolite, found in pegmatite at Craveggia, Piedmont. In chemical composition it is near to ilmenorutile. Named after Professor Giovanni Strüver, of Rome. Not the strüverite of A. Brezina, 1876.

Synkysit. O. B. Boeggild, Mineralogia Groenlandica, Copenhagen, 1905, p. 167. Variant of synchysite (G. Flink, 1901).

Tarbuttite. L. J. Spencer, 1907. Nature, vol. lxxvi, p. 215. Hydrous phosphate of zinc occurring as colourless or faintly coloured, anorthic crystals with descloizite at the Rhodesia Broken Hill mines, North Western Rhodesia. The crystals have a perfect cleavage in one direction, through which emerges obliquely the acute, negative bisectrix of the optic axes. Named after Mr. Percy Coventry Tarbutt, a director of the mining company, who furnished the material for determination.

Teallite. G. T. Prior, 1904. Min. Mag., vol. xiv, p. 21. Sulphostannite of lead, $PbSnS_2$, occurring as black, metallic, soft, and flexible folia resembling graphite, which are orthorhombic with a perfect basal cleavage. Named after Dr. J. J. Harris Teall, Director of the Geological Survey of Great Britain. From Bolivia; R. Koechlin (Min. Petr. Mitt. (Tschermak), 1905, vol. xxiv, p. 114) gives a more definite locality.

Thorianite. W. R. Dunstan, 1904. Nature, vol. lxix, p. 510; Bull. Imp. Inst. London, 1904, vol. ii, p. 13; 1905, vol. iii, p. 155. W. R. Dunstan and G. S. Blake, Proc. Roy. Soc. London, 1905, ser. A, vol. lxxvi, p. 253. W. R. Dunstan and B. M. Jones, Proc. Roy. Soc. London, 1906, ser. A, vol. lxxvii, p. 546. A heavy, black mineral found as water-worn, cubic crystals in the gem-bearing gravels of Ceylon. It was first described as uraninite (A. K. Coomaraswamy, Spolia Zeylanica, 1904, vol. i, p. 112; Administration Reports, Ceylon, for 1903, 1904, part iv, p. L 11), but it differs from this in that the uranium oxide (UO_2) is largely replaced isomorphously by thoria (68·8—78·8 per cent. ThO_2). So named because of the large amount of thorium which it contains.

Titanaugite. A. Knop, 1892. Der Kaiserstuhl im Breisgau. Leipzig, p. 72 (Titan-Augit). Titaniferous augite.

Titaneisenglimmer. H. Rosenbusch, 1885. Mikroskopische Physiographie d. Mineralien, 2nd edit., vol. i, p. 331. Ilmenite as thin, transparent scales of a clove-brown colour by transmitted light; described by K. Hofmann (1879) in basaltic rocks from Hungary. *See* Ilmenitglimmer.

Titanmelanite. A. Knop, 1892. Der Kaiserstuhl im Breisgau. Leipzig, p. 145 (Titanmelanit). Titaniferous melanite approaching schorlomite in composition.

Trechmannite. R. H. Solly, 1904. Min. Mag., 1905, vol. xiv, pp. 75, 189. (A preliminary description of the unnamed mineral appeared in Nature, 1903, vol. lxix, p. 142, and the name (Trechmannit) was first printed in Min. Petr. Mitt. (Tschermak), 1904, vol. xxiii, p. 552.) G. F. H. Smith and G. T. Prior, Min. Mag., 1907, vol. xiv, p. 300. Minute, red crystals associated with tennantite, &c., in the white, crystalline dolomite of the Binnenthal, Switzerland. The crystals are rhombohedral with parallel-faced hemihedrism, and were found to contain silver and arsenic: probably a sulpharsenite of silver. Named after Dr. Charles O. Trechmann, of Castle Eden, Co. Durham.

Tschernichewite. L. Duparc and F. Pearce, 1907. Compt. Rend. Acad. Sci. Paris, vol. cxliv, p. 763 (tschernichéwite). A variety of amphibole occurring with magnetite in a quartzite in the northern Urals. It is defined by its optical characters: the plane of the optic axes is perpendicular to the plane of symmetry and the axial angle is near 90°; $\gamma : c = 4°$; the pleochroism is very strong. These characters point to a soda-iron-amphibole near riebeckite or arfvedsonite; compare osannite. Named after Theodosij Nikolajevič Černyšev (Tschernyschew), Director of the Geological Survey of Russia.

Tychite. S. L. Penfield and G. S. Jamieson, 1905. Amer. Journ. Sci., ser. 4, vol. xx, p. 217; Zeits. Kryst. Min., vol. xli, p. 235. Octahedral crystals indistinguishable in appearance from northupite, and differing from this in containing sodium sulphate in place of sodium chloride, the formula being $2MgCO_3 . 2Na_2CO_3 . Na_2SO_4$. Amongst several thousand crystals of northupite from Borax Lake, San Bernardino Co., California, only four crystals of tychite were found, and the first one only by the merest chance, hence the name, from τύχη, luck. The formula was determined by the analysis of artificially prepared crystals. Mixed crystals containing the northupite and tychite molecules in varying proportions have been prepared by A. de Schulten (Compt. Rend. Acad. Sci. Paris, 1906, vol. cxliii, p. 403).

Weinbergerite. F. Berwerth, 1906. Min. Petr. Mitt. (Tschermak), vol. xxv, p. 181 (Weinbergerit). Radially-fibrous aggregates occurring with diopside and bronzite in the meteoric iron of Kodaikanal, India. The optical characters agree with orthorhombic symmetry. $(Na,K)_2O\,.\,6(Fe,Ca,Mg)O\,.\,Al_2O_3\,.\,8SiO_2$ or $R'AlSiO_4 + 3R''SiO_3$. Named after J. Weinberger, of Vienna.

Winchite. L. L. Fermor, 1906. Trans. Mining and Geol. Inst. India, vol. i, p. 79. A blue amphibole closely allied to tremolite in chemical composition, but containing also iron, sodium, potassium, and manganese. Found by Howard J. Winch with manganese-ores in Central India. A preliminary description of the mineral was given by L. L. Fermor in 1904 (Records Geol. Survey India, vol. xxxi, p. 235).

Xalostocite. (Collection de Minéralogie du Muséum d'Histoire Naturelle, Paris, Guide du Visiteur, 2nd edit., 1900, p. 49.) The pink grossularite occurring in white marble at Xalostoc, Morelos, Mexico. See Landerite.

Yttrocalcite. E. S. Fedorov, 1905. Gornyi Zhurnal, St. Petersburg, year lxxxi, vol. iii, p. 264 (иттрокальцить). Described as a fluoride of calcium, yttrium, and cerium, but found on further examination to be identical with fluor-apatite (Ann. Rep. Progr. Chem. Soc. London, 1907, for 1906, vol. iii, p. 311).

Yttrocrasite. W. E. Hidden and C. H. Warren, 1906. Amer. Journ. Sci., ser. 4, vol. xxii, p. 515; Zeits. Kryst. Min., 1907, vol. xliii, p. 18. Hydrous titanate of yttrium-earths, thorium, uranium, &c., found in Burnet Co., Texas, as black, orthorhombic crystals with a pitchy lustre and uneven fracture. Apparently so named because of its resemblance in appearance to polycrase (from κρᾶσις, a mixing), though it contains no more yttrium than does polycrase.

Zeiringit. *See* Zeyringite.

Zeolite mimetica. G. D'Achiardi, 1906. Atti Soc. Toscana Sci. Nat., Mem., vol. xxii, p. 160. A zeolitic mineral from Elba was determined to have the form of octagonal prisms built up of sectors with different optical orientation, and to have the composition $(Ca,K_2,Na_2)_3Al_4(Si_2O_5)_9\,.\,14H_2O$. Had the author been in no doubt as to this being really a new mineral he would not have hesitated to call it 'dachiardite' (p. 164) in memory of his father, Antonio D'Achiardi (1839–1902); for the present, however, he prefers to call it 'zeolite mimetica'.

Zeyringite. — Pantz, 1811. Taschenb. Min. (Leonhard), vol. v, p. 373 (Zeyringit). A finely fibrous, greenish-white or sky-blue calcareous sinter containing nickel, from Zeyring, Styria. It is placed under aragonite by V. von Zepharovich (Min. Lexicon Österreich, 1859, vol. i, p. 28) and E. Hatle (Die Minerale des Herzogthums Steiermark, 1885, p. 68); the latter spells Zeiringit.

SYSTEMATIC CLASSIFICATION OF NEW MINERALS[1].

Element.

Phosphorus.

Silicide.

Moissanite, CSi.

Sulphide.

Patronite, (vanadium sulphide ?).

Sulpharsenites, &c.

Teallite, $PbSnS_2$.
Smithite, $AgAsS_2$.
Hutchinsonite, $(Tl,Cu,Ag)_2PbAs_4S_8$.
Trechmannite. (Contains Ag,As.)
Lengenbachite, $Pb_6(Ag,Cu)_2As_4S_{13}$.
Marrite.

Haloids.

Cryolithionite, $Li_3Na_3Al_2F_{12}$.
Kleinite, $Hg_4Cl_2O_3$.
Paratacamite, $Cu_2Cl(OH)_3$.
Chlormanganokalite, $MnCl_2 . 4KCl$.

Oxides.

Thorianite, $(Th,U)O_2$.
Coronadite, $(Pb,Mn)O . 3MnO_2$.
Hollandite,
$m(Ba,Mn)_2MnO_5 + nFe_4(MnO_5)_3$.
Ebelmenite, var. of psilomelane.
Romanechite, „ „

Carbonates.

Kutnohorite, $(Ca,Mn,Fe,Mg)CO_3$.
Rutherfordine, $UO_2 . CO_3$.
Tychite,
$2MgCO_3 . 2Na_2CO_3 . Na_2SO_4$.
Otavite, basic Cd carbonate.
Giorgiosite,
$4MgCO_3 . Mg(OH)_2 . 4H_2O$.

Sulphates.

Metanhydrite, $CaSO_4$.
Palmierite, $PbSO_4 . (K,Na)_2SO_4$.
Sommairite, $(Fe,Zn)SO_4 . 7H_2O$.
Doughtyite,
$Al_2(SO_4)_3 . 5Al_2(OH)_6 . 21H_2O$.

Phosphates.

Podolite, $3Ca_3(PO_4)_2 . CaCO_2$.
Purpurite, $2(Mn,Fe)PO_4 . H_2O$.
Gorceixite,
$BaO . 2Al_2O_3 . P_2O_5 . 5H_2O$.
Harttite,
$SrO . 2Al_2O_3 . P_2O_5 . SO_3 . 5H_2O$.
Palmerite, $HK_2Al_2(PO_4)_3 . 7H_2O$.
Kertschenite,
$(Fe,Mn,Mg)O . Fe_2O_3 . P_2O_5 . 7H_2O$.
Paravivianite,
$(Fe,Mn,Mg)_3(PO_4)_2 . 8H_2O$.
Tarbuttite, Hyd. phosp. Zn.

[1] Only the more important of the names given in the above alphabetical list are here included.

Borate.

'Octahedral borax,' $Na_2B_4O_7 . 5H_2O$.

Tantalates, Titanates, &c.

Marignacite.
Blomstrandine.
Priorite.
Yttrocrasite.
Strüverite.

Silicates.

Isorthose, var. of orthoclase.
Baryta-orthoclase.
Paracelsian, $Ba_3Al_8Si_8O_{31}$.
Tschernichewite, var. of amphibole.
Soretite, ,, ,,
Osannite, ,, ,,
Winchite, ,, ,,
Magnesium-diopside.
Blanfordite, var. of pyroxene.
Soda-leucite.
Landerite, var. of grossularite.
Naegite [= zircon ?].
Californite, var. of idocrase.
Beckelite, $Ca_3Ce_4(Si,Zr)_3O_{15}$.
Weinbergerite, $(Na,K)_2(Fe,Ca,Mg)_6Al_2Si_8O_{26}$.
Beryllium-humite, $(Mg,Be)_5(MgOH)_2(SiO_4)_3$.
Oehrnite, $6(Mg,Fe,Ca)SiO_3 . H_2O$.
Hibschite, $H_4CaAl_2Si_2O_{10}$.
Astrolite, $(Al,Fe)_2Fe''(Na,K)_2(SiO_3)_5 . H_2O$.
Silicomagnesiofluorite, $H_2Ca_4Mg_3Si_2O_7F_{10}$.
Erikite, hyd. sil. and phosphate, Ce,Al,Ca,Na.
Morencite, $H_{22}(Mg,Ca)_2Fe_6'''(SiO_4)_{11}$.
Radiotine, $H_4Mg_3Si_2O_9$.
Nemaphyllite, $H_4Mg_3Si_2O_9$.
Nepouite, $(Ni,Mg)_3Si_2O_7 . 2H_2O$.
Chocolite, hyd. sil. Fe,Ni,Mg.
Greenalite, $Fe'''_2(Fe,Mg)_3(SiO_4)_3 . 3H_2O$.
Irvingite, var. of lithia-mica.
Moravite, $H_4(Al,Fe)_4(Fe,Mg)_2Si_7O_{24}$.
Stilpnochlorane, $H_{24}(Al,Fe)_{10}(Ca,Mg)Si_9O_{46}$.
Zeolite mimetica, $(Ca,K_2,Na_2)_8Al_4(Si_2O_5)_9 . 14H_2O$.
Reyerite, hyd. sil. Ca,Al.

Hydrocarbons.

Denhardtite.
N'hangellite.

July, 1907.

REVIEWS.

Rock Minerals: their Chemical and Physical Characters and their Determination in thin Sections. By Joseph P. Iddings. Pp. xii + 548, with 438 text-figures and one coloured plate. (New York: John Wiley & Sons; London: Chapman & Hall, 1906. Price 21*s.* net.)

This extremely valuable treatise on rock-forming minerals covers practically the same ground as the same author's translation and abridgement of Rosenbusch's 'Microscopical Physiography of Rock-making Minerals', which between 1888 and 1898 passed through four English editions; it is evidently intended to take the place of a translation and abridgement of the still more extensive fourth edition of the German work prepared by Rosenbusch and Wülfing. In many respects the present volume is a distinct improvement on the translated work. The arrangement of the subject-matter under prominent headings makes the volume much more useful for purposes of reference.

The first part, dealing with general principles and methods of research, extends to 200 pages, half of which is devoted to optical properties. In the second, and larger, part is given a detailed description of the various rock-forming minerals. Information respecting each mineral is clearly put forth under the following headings:—chemical composition; alteration; crystallographic characters (including twinning and cleavage); optical properties (and colour); inclusions; modes of occurrence; resemblances to, and differences from, other minerals; laboratory production. Some of the longer descriptions are preceded by a summary of the characters of the mineral, or, in the case of groups of minerals, by a general account of the group. The minerals are classified on a chemical basis, and this seems more rational than the classification according to systems of crystallization as adopted by Rosenbusch.

At the end of the volume are given useful tables of optical constants, which have the advantage of being printed on the pages rather than on inconvenient folding sheets. The coloured plate exhibiting the birefringence of minerals is borrowed from Lévy and Lacroix.

The book is one to be recommended to all students of petrology, but it would perhaps have been more generally useful if references to the literature had been quoted under each mineral. A few misprints have been noticed, especially in the spelling of the names of minerals.

Physikalische Kristallographie vom Standpunkt der Strukturtheorie. By ERNST SOMMERFELDT. Pp. vi + 132, with 122 illustrations. (Leipzig: C. H. Tauchnitz, 1907. Price 6 marks.)

EVEN with the addition of the last four words, which on the title-page are appended in smaller type and on the cover do not appear at all, the scope of the book can scarcely be said to be defined with much precision by its title. Far from dealing with the general characters of crystals and the methods and apparatus in use for their determination, Dr. Sommerfeldt confines himself, except in the last chapter, to a discussion of the various types of crystal-structure, the point-systems of Sohncke being treated in far greater detail. The proper comprehension of the symmetry appertaining to the several systems is considerably facilitated by the series of photographic reproductions of the actual models, which were constructed under the direction of Sohncke, and are preserved at Munich. The absence of relief unavoidable in such illustrations, unless presented in pairs for observation with a stereoscope, is to some extent compensated by a plan placed beside each illustration; unfortunately many of the latter diagrams are far from distinct. After defining in this way the 65 point-systems, the author determines, somewhat too cursorily, the remaining 165 systems possible in crystals by means of the method due to Barlow. This procedure is more easily understood by most crystallographers than the mathematical method of Schönflies, and it has the advantage of distinguishing clearly the enantiomorphous systems from those possessing mirror-image symmetry.

In the concluding chapter, Dr. Sommerfeldt treats briefly of many interesting physical questions closely connected with the discussion of crystal-structure; such as the etching-figures, which have thrown so much light on the internal symmetry of certain substances; the rotation of the plane of polarization, a phenomenon which can only be satisfactorily explained by the existence of some helical arrangement in the structure; cleavage, which suggested to Haüy the idea of a primitive form; isomorphism, morphotropy, and polymorphism; twinning; and the cause of the habit of crystals. The chapter ends with a discussion of the well-known case of pseudo-trigonal symmetry, which can be obviated only by admitting the idea of a grained structure.

Despite a want of balance in the discussion and some inexactitude in the reasoning, the book is one which may be commended to the reader who desires a comparatively simple exposition of the difficult and important subject of crystal-structure.

NOTES.

The following deaths have to be recorded:—

Ludwig Brackebusch died at Hanover on June 2, 1906, at the age of fifty-seven. For many years he was Professor of Mineralogy and Geology in the University of Córdoba, Argentina, and he was the author of several papers on Argentine minerals. The mineral brackebuschite was named after him.

William Paget Jervis (1831–1906) was born in India, where his father, Colonel T. B. Jervis, was engaged on the Topographical Survey, and after an English education and some practical experience in Cornish mining, he was appointed Conservator of the Royal Italian Industrial Museum at Turin. He published several papers on the mineral resources of Italy, and his 'I tesori sotterranei dell' Italia' (4 vols., 1873–89) is a monument of patient and painstaking industry. He was created a Cavaliere by the King of Italy.

Henri Moissan (1852–1907), the celebrated French chemist, died on February 20, 1907, following an operation for appendicitis. Since 1900 he had been Professor of Inorganic Chemistry at the Sorbonne. On January 10 of this year he was elected President of the French Mineralogical Society. His researches on meteoric irons and on the artificial production of diamond are well known. A meteoric mineral recently isolated by him has been named moissanite.

Viktor Ivanovič Vorobjev (V. von Worobieff), Conservator of the collection of minerals in the Geological Museum of the Academy of Sciences at St. Petersburg, was killed on a glacier in the Caucasus, in August, 1906, at the early age of thirty-one. His elaborate paper on the crystalline form and pyroelectric properties of tourmaline gave promise of further useful work.

John Francis Walker (1839-1907), an original member of this Society, died at York, his native city, on May 23, 1907. He made geology, and more particularly British fossil brachiopods, his special study, though at one time he was a University teacher in chemistry at Cambridge

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The Chair of Mineralogy at the University of Bonn, rendered vacant by the resignation of Professor H. Laspeyres, has been filled by Professor R. Brauns, whose place at Kiel has been taken by Professor E. A. Wülfing, of the Technical High School of Danzig; the last-named place being

now filled by Dr. F. von Wolff. Professor L. Milch, of Breslau, goes to Greifswald as successor to the late E. Cohen, and Dr. C. M. Viola becomes Professor of Mineralogy at Parma.

The seventieth birthdays of Professors H. Rosenbusch and G. Tschermak, celebrated last year (1906), were marked by the publication of a 'Harry Rosenbusch Festschrift' and of a special number of 'Tschermak's Mineralogische und Petrographische Mitteilungen', in which are given excellent portraits of these well-known workers in petrology and mineralogy respectively.

The extensive private collection of minerals and fossils formed during the course of many years by the late Miss Caroline Birley (1851–1907) has been bequeathed by her to the Trustees of the British Museum and to the Manchester Museum in the University of Manchester. The collection is particularly rich in zeolites, and more especially in zeolites from the Faroe Islands. Shortly before Miss Birley's visits to this locality in 1889 and 1890, there had been an extensive fall of rock, and she was thus fortunately able to collect many fine specimens. The description of 'sphaerostilbite', published in this magazine (1898, vol. xii, pp. 26–9), was based on material in Miss Birley's collection.

The unique collection of jade presented by Mr. Heber R. Bishop to the Metropolitan Museum of Art in New York is described in two huge volumes entitled 'Investigations and Studies in Jade' (New York, 1906). The volumes measure 19 × 26 inches, and weigh respectively 70 and 55 pounds. The paper, printing, and binding are of the best obtainable, whilst the plates are veritable works of art, reproducing the translucency and colour of the mineral with extraordinary faithfulness. In addition to the catalogue of the collection, there are several articles, contributed by well-known experts, dealing with jade (nephrite and jadeite) from every possible point of view. The mineralogical portion, of which Dr. G. F. Kunz had charge, contains articles by Max Bauer, F. Berwerth, F. W. Clarke, A. A. Damour, J. P. Iddings, L. A. Jaczewski, G. F. Kunz, A. B. Meyer, C. Palache, S. L. Penfield, L. V. Pirsson, S. H. Washington, and E. Weinschenk, besides fifty-eight new analyses by P. T. Walden and H. W. Foote. The work was privately printed and the edition limited to 100 copies, which have been distributed amongst the important libraries of the world, a dozen copies coming to the United Kingdom. Unfortunately Mr. Bishop did not live to see the completion of this truly remarkable work.

INDEX TO VOL. XIV.

(See also 'List of New Mineral Names,' p. 394.

Aegirite-riebeckite-gneiss from Ross-shire, 119.
Albite from Binnenthal, 16.
— German East Africa, 178.
Allen (E. T.), synthesis of minerals, 281.
Allophane from Wales, 168.
Alum, crystallization of, 134.
Amethyst from German East Africa, 178.
Amiantos of ancients = chrysotile, 143.
Ammonium haloids, 235.
Amphibole in serpentine-rock, 366.
Anatase in Cleveland ironstone, 96, 98.
— from Binnenthal, 16.
Andorite from Bolivia, 316.
— systematic position of, 319.
Antigorite in serpentine-rock, 368.
Antimonite, optical characters, 199.
Apatite from Bolivia, 338.
Appointments to chairs of mineralogy, 418.
Arsenopyrite, *see* Mispickel.
Augelite from Bolivia, 323.
Aurichalcite from Cornwall, xxviii.
— Co. Wicklow, 349.

Babel-quartz from Cornwall, xxvii.
Baddeleyite from Ceylon, 378.
Balance-sheet, xxiv, xxx, xl, xliv.
Barker (T. V.), regular growth of soluble salts on each other, 235.
— elected member, xxv.
Barlow (W.), atom-arrangements of crystals in carbon compounds, xxii.
Barrow (G.), axinite from Bodmin district, xxxvi.
Barytes from Binnenthal, 190.
— Co. Tipperary, 352.
Bastite in serpentine-rock, 370.
Baumhauer (H.), elected hon. member, xxxi.
Becke (F.), skiodroms, 276.
— measurement of optic axial angle from isogyres, 280.
Becker (G. F.) and Day (A. L.), linear force exerted by growing crystal, 197.
Behrens (T. H.), obituary, 118.
Bertrandite from Cornwall, xxvii.
Bethany meteorite, 35.
Binnenthal (Switzerland) minerals, xxxiv, xliii, 16, 72, 184, 204, 212, 283, 389.
Birley (Miss C.), collection, 419.
Bishop (H. R.), collection of jade, 419.
Blake (G. S.), elected member, xxxvi.
— and Smith (G. F. H.), baddeleyite from Ceylon, 378.
Blende with metallic lustre, from the Binnenthal, 81.
Boeggild (O. B.), 'Mineralogia Groenlandica,' 195.
Bolivian minerals, 21, 208, 308, 345.
— rocks, 335.
Bonney (T. G.), obituary of C. A. McMahon, 56.
Bornite, formula of, 120.
Bowman (H. L.), hamlinite from Binn, 389.
— bertrandite from Cornwall, xxvii.
Bowmanite, 80, 389, 396.
Brackebusch (L.), obituary, 418.
British minerals, xxvii, xxviii, xxxvi, xxxix, 93, 96, 98, 109, 116, 118, 167, 207, 311, 348, 350, 385.
Brookite in Cleveland ironstone, 96.
Butler (F. H.), silver-ore in Perran mine, Cornwall, 385.
Bye-laws, vii.

Caesium haloids, 235.
Calamine-ore from Co. Tipperary, 351.
Caledonite from Co. Wicklow, 348.
Campbell (D. F.), elected member, xix.
Canadian economic minerals, 196.
Cape of Good Hope meteorite, 37.
Caperr meteorite, 41.
Carborundum, 121, 396.
Cassiterite from Bolivia, 332.
— Ross-shire, 118.
— pseudomorphs from Bolivia, 345.
Cerargyrite from Cornwall, 385.
Cerrussite, angles, 51.
Ceylon, minerals from, 43, 160, 194, 378.

Chalcostibite from Bolivia, 322.
Chalybite from Bolivia, 342.
— Cornwall, 385.
Chapman (E. J.), obituary, 65.
Chemical analysis of rocks, 115.
Chevalier (J.), crystallization of potash-alum, 134.
— and Miers (H. A.), crystallization of sodium nitrate, 123.
Chlormanganokalite, 397.
Chlornatrokalite, 397.
Chrysotile from Canada, 196.
— Cyprus, 143.
— in ancient writings, 143.
Church (A. H.), handbook of precious stones, 194.
Claremont (L.), the gem-cutter's craft, 275.
Cleve (P. T.), obituary, 194.
Cleveland ironstone, brookite, &c. in, 96.
Clinochlore in serpentine-rock, 367.
Cohen (E. W.), obituary, 194.
Colombia (S. America), minerals, 196.
Copper from Bolivia, 309.
Cornish minerals, xxvii, xxviii, xxxvi, 311, 385.
Corundum from German East Africa, 178.
Crook (T.), elected member, xli.
— and Jones (B. M.), geikielite and the ferro-magnesian titanates, 160.
Crystal-structure, 417.
Crystallization of sodium nitrate, 123.
— of potash-alum, 134.
— spontaneous, 123, 134.
— by inoculation, 123, 134.
— force of, 197.
Crystallographic projections, 99.
Crystals, thirty-two classes, 261, 360.
— irregular development, 43.
'Cullinan' diamond, 119.
Cumenge (E.), obituary, 65.
Curie (P.), obituary, 273.
Currie (J.), new localities for gyrolite and tobermorite, 93.
Cylindrite, analysis, 25.

D'Achiardi (A.), memorial volume, 68.
Day (A. L.), synthesis of minerals, 281.
Diamond, 'Cullinan,' from Premier mine, Transvaal, xxviii, 119.
Diopside from German East Africa, 179.
Domingite = jamesonite, 207.
Double salts, 321.
Drawing of crystals, 120.
Dufret (J. B. H.), obituary, 194.
Dundasite from Wales, 167.

'Economic Geology,' 196.
Enargite from Bolivia, 344.
Epidote, angles, 52.
— optical constants and chem. comp., 113.
— from Inverness-shire, 109.
Erubescite, formula of, 120.
Evans (J. W.), new forms of quartz-wedge, 87.
— identity of the amiantos or Karystian stone of the ancients with chrysotile, 143.
— gnomonic projection on two planes, 149.
— determination of optic axial angle in parallel light, 157.
— skiodroms and isogyres, 230.
— thirty-two classes of symmetry, 360.

Færöes, zeolites, 94, 419.
Feather-ore, 207.
Fichtelite, cryst., 197.
Fiedlerite, composition of, 121.
Fletcher (L.), meteoric irons from Great Namaqualand, 28.
— meteoric irons labelled 'Cape of Good Hope' and 'Great Fish River', 37.
— meteoric iron from Caperr, Patagonia, 41.
— obituary of H. P. Gurney, 61.
Fletcher (M.), cobaltiferous mispickel from Norway, 54.
Fluorite from Bolivia, 337.
Foster (C. Le N.), obituary, 57.
Fouqué (F. A.), obituary, 64.
Fowler (A.), spectroscopic determinations by, 384.
Franckeite, analysis, 24.

Geikielite analyses, 160.
— alteration products, 164.
German East Africa, phenacite, &c., 178.
Glauberite, pseudomorphs of opal after, 198.
Glimmerzeolith, 95, 409.
Gnomonic net, 18.
— projection, 104, 149.
Goniometer, three-circle, 1.
— signal, 4.
Goodchild (J. G.), obituary, 271.
Goodchild (W.), elected member, xxvii.
Grabham (G. W.), elected member, xix.
Great Fish River meteorite, 37.
Great Namaqualand, meteoric irons, 28.

Greenland, minerals of, 95, 195.
Greg (R. P.), obituary and portrait, 268.
Groth (P. von), 'Physikalische Krystallographie,' 195.
— testimonial to, portrait of, 66.
Growth, regular, of salts on each other, 235.
Guejarite from Bolivia, 322.
Gurney (H. P.), obituary, 61.
Gypsum crystals from chemical works, 211.
Gyrolite, new localities for, 93.

Hallowes (K. A. K.), apparatus for determining sp. gr. of grains, xxviii.
Hamlinite from Binn, 389.
Harrington (B. J.), formula of bornite, 121.
— isomorphism in magnetite, 373.
Hartley (H.), apparatus for separating minerals with heavy liquids, 69.
— microscopic heating stage, xxxvi.
— and Thomas (N. G.), pseudomorph of quartz after apophyllite from Tyrol, xxxvi.
Hatch (F. H.) and Corstorphine (G. S.), large diamond from Transvaal, xxviii, 119.
Heavy liquids, separating apparatus, 69.
Hemimorphite from Co. Tipperary, 351.
Hilton (H.), gnomonic net, 18.
— construction of crystallographic projections, 99.
— gnomonic projection, 104.
— thirty-two classes of symmetry, 261.
— brushes in convergent light, 281.
— elected member, xlii.
Hohmann (T.), collection, 309, 344.
Hopeite from Rhodesia, xliii.
Hornfels, tourmaline-, from Bolivia, 385.
Hudson (R. W. H. T.), obituary, 118.
Hutchinson (A.), mineralogical chemistry, 120.
— optical characters of antimonite, 199.
— chemical composition of lengenbachite, 204.
Hutchinsonite, 72, 284, 400.
Hyalophane from Binnenthal, 16, 190.

Iddings (J. P.), rock minerals, 416.
Identities, minerals, 121.
Ilmenite, magnesium, 165.
— from Binnenthal, 184.
Ilmenite, Brazil, 258.
Indices of faces, determination of, with moriogram, 49.
International Catalogue of Scientific Literature, xxii, xxviii, xxxv, xlii.
Irish minerals, 348, 350.
Iron-pyrites from Hungary, 68.
Ironstone, brookite, rutile, and anatase in, 96.
Isogyres and skiodroms, 159, 230, 276, 281.
Isomorphism in magnetite, 373.

Jade collection of H. R. Bishop, 419.
Jamesonite, chem. formula, 312.
— and feather-ore, 207.
— from Bolivia, 310.
Japanese minerals, 117, 120.
Jarosite from Bolivia, 342.
Jervis (W. P.), obituary, 418.
Johnston-Lavis (H. J.) and Spencer (L. J.), chlormanganokalite, xliii.
Jones (B. M.), elected member, xxxi.
— and Crook (T.), geikielite and the ferro-magnesian titanates, 160.
Judd (J. W.), obituary of C. Le N. Foster, 57.
— — F. Rutley, 59.

Kaolin from German East Africa, 179.
Karystian stone = chrysotile, 143.
Kylindrite, 25.

Labile and metastable solutions, 123, 134.
Laumontite from Binnenthal, 16.
Lead sulphantimonites, 210.
— sulpharsenites, 206.
Lengenbachite, 78, 204, 402.
Leucoxene, 164.
Lewis (W. J.), Pyroxene and albite, xxxiii.
Linarite from Co. Wicklow, 348.
Lindsey (C. R.), brookite in Cleveland ironstone, 96.
Lion River meteorite, 31, 34.
Localities of minerals, inconsistencies in statements of, 68.

McMahon (C. A.), obituary, 56.
Magnetite from Ross-shire, 119.
— titaniferous, from Canada and Arkansas, 373.
Marrite, 76, 188, 403.
Mears (J. B.), elected member, xli.
Members, list of, xi.
Metastable and labile solutions, 123, 134.
Meteoric irons from S. Africa, 28, 37.
— — Caperr, Patagonia, 41.

Miargyrite from Bolivia, 339, 340.
Mica mines in Canada, 196.
Micaceous zeolite, 95, 409.
Miers (H. A.), Kimberley diamond mines, xxiii.
— danalite from Cornwall, xxvii.
— barium-radium bromide, xxvii.
— experiments bearing on the order of crystallization of rock-constituents, xli.
— obituary of S. L. Penfield, 264.
— and Chevalier (J.), crystallization of sodium nitrate, 123.
Mineral-veins in Co. Tipperary, 350.
— Cornwall, 385.
Mineralogical chemistry, report of progress, 120.
Minerals, list of identities, 121.
— new names, 394.
Mispickel from Bolivia, 334.
— cobaltiferous, from Norway, 54.
Moissan (H.), obituary, 418.
Moissanite, 121, 404.
Moissenet (V. L.), obituary, 272.
Molecular volumes and parallel growth of crystals, 248.
Monoclinic-hemimorphic class, 197.
Moriogram, 49.
Morphotropic relations, 322.
Mukerop meteorite, 34.
Muscovite from German East Africa, 179.

Naegite, 117, 404.
Namaqualand, Great, meteoric irons, 28.

Obituaries :—
Behrens (T. H.), 118.
Brackebusch (L.), 418.
Chapman (E. J.), 65.
Cleve (P. T.), 194.
Cohen (E. W.), 194.
Cumenge (E.), 65.
Curie (P.), 273.
Dufret (J. B. H.), 194.
Foster (C. Le N.), 57.
Fouqué (F. A.), 64.
Goodchild (J. G.), 271.
Greg (R. P.), 268.
Gurney (H. P.), 61.
Hudson (R. W. H. T.), 118.
Jervis (W. P.), 418.
McMahon (C. A.), 56.
Moissan (H.), 418.
Moissenet (V. L.), 272.
O'Reilly (J. P.), 118.
Penfield (S. L.), 264.
Rutley (F.), 59.
Schmidt (S.), 65.
Obituaries (*continued*) :—
Soret (C.), 65.
Vorobjev (V. I.), 418.
Walker (J. F.), 418.
Ward (H. A.), 273.
Optic axial angle, determination of, from isogyres, 280.
— determination of, in parallel light, 157.
Optical characters of stibnite, 199.
Orange River district meteorite, 36.
O'Reilly (J. P.), obituary, 118.
Orpiment from Co. Tipperary, 352.
Orthoclase from German East Africa, 178.

Parallel growth of crystals, 235, 327.
Paratacamite, 170, 406.
Parkinson (J.), elected member, xl
Pearce (R.), cassiterite pseudomorphs from Bolivia, 345.
Penfield (S. L.), elected hon. member, xxi.
— obituary and portrait, 264.
Peru, 'Boletin . . . de Minas,' 196.
Phenacite from Cornwall, xxviii.
— German East Africa, 178.
Picroilmenite from Ceylon, analyses, 165.
Plumosite, 207.
— from Bolivia, 315.
Polymorphism in zircon, 48.
Potash-alum, crystallization of, 134.
Potassium haloids and cyanide, 235.
Precious stones, cutting, 275.
Premier diamond mine, Transvaal, 119.
Prior (G. T.), Teallite, franckeite and cylindrite, 21.
— dundasite from Wales, 167.
— analyses by, 170, 308.
— and Smith (G. F. H.), red silver minerals from Binn, 283.
— and Solly (R. H.), zinciferous tennantite from Binn, xlii.
— and Zambonini (F.), strüverite, xlii.
Projections, crystallographic, 99.
— gnomonic, 18, 104, 149.
Proustite from Binnenthal, 189.
Pseudomorphous cassiterite from Bolivia, 345.
Pseudomorphs ('pine-apple') of opal, 197.
Pyrites, *see* iron-pyrites.
Pyrophyllite from Bolivia, 324, 335.
Pyrostilpnite from Bolivia, 328.
Pyroxene in serpentine-rock, 365.

Quartz-wedge, new forms of, 87.
— use of, 157.

Radium-barium bromide, cryst., xxvii.
Rashleigh collection, xxi.
Rastall (R. H.), elected member, xix.
Refractive index diagram, 191.
Refractometer, improved form, 83, 354.
Regular growth of soluble salts on each other, 235.
— tetrahedrite and stannite, 327.
Reinite, a pseudomorph, 117.
Reviews of books, 115, 275, 416.
Riebeckite from Ross-shire, 119.
Rock-forming minerals, 416.
— synthesis of, 281.
Rocks, chemical analysis of, 115.
— from Bolivia, 335.
Rosenbusch (H.), 419.
— 'Mikroskopische Physiographie,' 195.
Rubidium haloids and cyanide, 235.
Rudler (F. W.), handbook of British minerals, 116.
Russell (A.), linarite and caledonite in Co. Wicklow, 348.
— Silvermines district, Co. Tipperary, 350.
— new mineral localities in Cornwall and Devon, xxviii.
— exhibition of Cornish minerals, xxvii, xxviii, xxxiii, xxxix.
Rutile from alteration of geikielite, 164.
— in ironstone, 96, 98.
— from German East Africa, 178.
Rutley (F.), obituary, 59.

Sartorite from Binn, cryst., 212.
Schmidt (S.), obituary, 65.
Scotch minerals, 93, 109, 118.
Seligmannite, 82, 186.
Semseyite from Bolivia, 314.
Separating apparatus with heavy liquids, 69.
Serpentine-minerals, 368.
Serpentine-rock from Tarnthaler-Köpfe, Tirol, 365.
Silver-minerals from Binn, 283.
— Bolivia, 342.
Silver-ore in Cornwall, 385.
Skiodroms and isogyres, 230, 276.
Smith (G. F. H.), three-circle goniometer, 1.
— the moriogram, 49.
— improved form of refractometer, 83.
— paratacamite, a new oxychloride of copper, 170.
— determination of refractive indices, with diagram, 191.
— ilmenite from Brazil, 258.
— new model of refractometer, 354.
— obituary of R. P. Greg, 268.
Smith (G. F. H.), prismatic method of determining refractive indices, xxi.
— crystallographic determinations by, 184, 329, 331, 348.
— and Blake (G. S.), baddeleyite from Ceylon, 378.
— and Prior (G. T.), red silver minerals from Binn, 283.
Smithite, 74, 293, 409.
Smythe (J. A.), analysis by, 55.
Sodium haloids, 235.
Sodium nitrate, cystallization of, 123.
Solly (R. H.), anatase, &c., from Binn, 16.
— new minerals from Binn, 72.
— ilmenite, &c., from Binn, 184.
— the Lengenbach quarry, xxxix.
— and Prior (G. T.), zinciferous tennantite from Binn, xlii.
Sommerfeldt (E.), Physikalische Kristallographie, 417.
Soret (C.), obituary, 65.
South African meteorites, 28, 37.
Spencer (L. J.), zircon (sp. gr. 4.0) from Ceylon, 43.
— phenacite, &c., from German East Africa, 178.
— 'feather-ore'; identity of 'domingite' (= 'Warrenite') with jamesonite, 207.
— Bolivian minerals, jamesonite, tourmaline, &c., 308.
— list of new mineral names, 394.
— list of identities, 121.
— crystallographic determinations by, 345.
— pleochroism of adamite, xxi.
— and Johnston-Lavis (H. J.), chlormanganokalite, xliii.
Sphene from alteration of geikielite, 165.
Spherical triangles, solution of, with three-circle goniometer, 14.
Springbok River meteorite, 35.
Stannite, regular grouping with tetrahedrite, 327.
Stibnite, optical characters, 199.
— plumose, 208.
Story-Maskelyne (N. S.), letter to P. Groth, 66.
Symmetry, thirty-two classes of, 261, 360.
— axes of, 360.
Synthesis of rock-forming minerals, 281.

Tarbuttite, 411.
Teallite, 21, 411.
Tetrahedrite from Bolivia, 325.

Tetrahedrite, regular grouping with stannite, 327.
Textbooks, reviews, 115, 195, 416.
Thomas (H. H.), epidote from Inverness-shire, 109.
Three-circle goniometer, 1.
Tin-ores, Bolivian, 332, 345.
Tobermorite, new localities for, 93.
Topic axes and parallel growth of crystals, 253.
Tourmaline from Bolivia, 333.
— German East Africa, 178.
Tourmaline-hornfels from Bolivia, 335.
Trechmann (C. O.), crystallography of sartorite, 212.
Trechmannite, 75, 189, 300, 412.
Tremolite in serpentine-rock, 366.
Tschermak (G.), 419.

Valentinite from Bolivia, 328.
Vivianite from Bolivia, 324.
Vorobjev (V. I.), obituary, 418.

Wada (T.), minerals of Japan, 117.
Wada (T.), 'Beiträge zur Mineralogie von Japan,' 120.
Walker (J. F.), obituary, 418.
Ward (H. A.), obituary, 273.
Warrenite = jamesonite, 207.
Washington (H. S.), manual of the chemical analysis of rocks, 115.
Wild meteorite, 32.
Withamite from Glencoe, 119.
Wolframite from Bolivia, 334.
Woodgate (J.), elected member, xxv.
Woodward (C. J.), gypsum crystals from chemical works, 211.
Worobieff (V. von), obituary, 418.

Young (A. P.), serpentine-rock from Tarnthaler-Köpfe, Tirol, 365.

Zambonini (F.) and Prior (G. T.), strüverite, xlii.
Zircon, irregular crystals from Ceylon, 43.
— modifications of, 48.
Zonal growth of crystals, 252.
Zone-axes, 360.

ERRATA.

VOL. VI.

Page.	Line.	
xix (Proc.)		An original specimen in the British Museum collection of the supposed 'lead chromate' with the formula '$4PbO.3CrO_3$' has been proved to be vanadinite. The metallic zinc is of doubtful origin.

VOL. X.

iii (Proc.)	1	*For* 1892–3, *read* 1891–2.

VOL. XI.

283	22	*For* Magnetite after Cerussite *read* Malachite after Cerussite.

VOL. XII.

13	17	*For* L. F. Navarro, *read* L. Fernández Navarro.
13 (footnote 2)		*For* Espanola, *read* Española.
98	9	*For* total percentage in the mineral, *read* total percentage of titanic acid in the mineral.
244	10*	*For* Rio Tequetinhonha, *read* Rio Jequitinhonha.
389	13*	*For* P. Groth, &c., *read* E. Hussak, Min. Petr. Mitt. (Tschermak), 1895, vol. xiv, p. 408.

VOL. XIII.

303	20	*For* (1831–1901), *read* (1831–1906).
364	17	*For* snow-white scales, *read* snow-white tufts. (See L. Brugnatelli, Centralblatt Min., 1903, p. 663.)

VOL. XIV.

29	5	*For* Milman, *read* Wilman.
184	—	The table of angles belongs to the first footnote.
201	21	*For* perpendicular to *c* (001), *read* parallel to *c* (001).
202	17	*For* optic axis, *read* optic axes.

* From bottom of page.

MINERALOGICAL MAGAZINE.

CONTENTS OF NO. 67.

(SEPTEMBER, 1907.)

PAGE

Proceedings of the Mineralogical Society xli

G. F. H. SMITH and G. T. PRIOR: Red silver minerals from the Binnenthal, Switzerland 283

L. J. SPENCER: Notes on some Bolivian minerals (Jamesonite, Andorite, Cassiterite, Tourmaline, &c.) 308

R. PEARCE: Cassiterite pseudomorphs from Bolivia . . 345

A. RUSSELL: On the occurrence of Linarite and Caledonite in County Wicklow 348

A. RUSSELL: Note on the mines and minerals of the Silvermines district, Co. Tipperary 350

G. F. H. SMITH: A new model of Refractometer . . . 354

J. W. EVANS: A simple arrangement and notation of the thirty-two classes of symmetry based on the symmetry of zone-axes 360

A. P. YOUNG: On a Serpentine-rock from the mass of the Tarnthaler-Köpfe, Tirol 363

B. J. HARRINGTON: Isomorphism as illustrated by certain varieties of Magnetite 373

G. S. BLAKE and G. F. H. SMITH: Baddeleyite from Ceylon . 378

F. H. BUTLER: On the occurrence of silver ore in the Perran mine, Perran Uthnoe, Cornwall 383

H. L. BOWMAN: On Hamlinite from the Binnenthal, Switzerland 389

L. J. SPENCER: A (fourth) list of new mineral names . . 394

Reviews 410

Notes 418

(Title-page, Contents, and Index to Vol. XIV.)

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